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MONTHLY WEATHER REVIEW

VOLUME 43, No. 9

SEPTEMBER, 1915



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SEPTEMBER, 1915.

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NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the Editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for the illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically requested when the manuscript is submitted.

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW will be prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology*.—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology*.—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere*.

SECTION 4.—*Rivers and floods*.

SECTION 5.—*Seismology*.—Results of observations by Weather Bureau observers, and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography*.—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month*.—Summary of local weather conditions; climatological data from regular Weather Bureau stations; Tables of accumulated and excessive precipitation; data furnished by the Canadian

Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and Chart No. IX of the North Atlantic Ocean, for August, 1914. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late. The first issue of this summary and accompanying chart will be found in this number.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospheric are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years were prepared by the 12 respective "district editors" are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected section centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month designated on the title page; hence, the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are especially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.

The Meteorological Service of Cuba.

The Meteorological Observatory of Belan College, Habana.

The Government Meteorological Office of Jamaica.

The Meteorological Service of the Azores.

The Meteorological Office, London.

The Danish Meteorological Institute.

The Physical Central Observatory, Petrograd.

The Philippine Weather Bureau.

CORRIGENDUM.

In the REVIEW for August, 1915, page 408, Table 1, for "Correction of +0.08 inch" read "Correction of -0.08 inch."

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASURED AT WASHINGTON, D. C., DURING SEPTEMBER, 1915.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., Oct. 15, 1915.]

In Table 1 are summarized the measurements of the intensity of direct solar radiation made by the Weather Bureau at the American University,¹ Washington, D. C., during September, 1915. The 8th to the 20th, inclusive, was a period of few clouds, with many days of continuous sunshine, but low radiation intensity. During the last decade the radiation intensities were above the normal. A noon reading of 1.45 calories, obtained on the 22d, is higher than any noon reading previously obtained at Washington in September. On the morning of the 27th, with the sun at zenith distance 66.5° to 48.3°, inclusive, the radiation intensities were higher than the corresponding intensities on the 22d, but clouds prevented the measurement of the intensity at noon. The monthly means are lower than the 5-year means published in the Bulletin of the Mount Weather Observatory, 1912, 5: 182.

TABLE 1.—Solar radiation intensities at Washington, D. C., during September, 1915.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.
September 8.....	1.18	0.84	0.63	.....	.....	0.43	0.39	0.35	.....	.....	.....
9.....	1.18	0.91	0.75	.....	.....	0.43	0.39	0.35	.....	.....	.....
10.....	1.18	0.94	0.80	0.71	0.63	0.55	0.48	0.43	0.38	0.34	.....
13.....	1.24	1.11	0.98	0.87	0.77	0.69	0.62	0.56	0.50	0.44	.....
14.....	1.37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16.....	.....	0.98	0.87	0.73	0.64	.....	.....	0.48	0.45	0.42	0.39
17.....	.....	.....	0.87	0.69	0.54	0.46	0.42	0.38	.....	.....	.....
20.....	1.50	1.40	1.28	1.20	1.14	1.06	1.01	0.97	0.92	0.87	.....
22.....	1.35	1.25	1.17	.....	.....	.....	.....	.....	.....	.....	.....
24.....	1.44	1.35	1.25	.....	.....	0.85	.....	.....	.....	.....	.....
27.....	1.34	1.24	1.15	1.07	1.00	0.94	0.88	0.83	0.79	0.76	.....
28.....	.....	.....	.....	.....	0.81	.....	.....	.....	.....	.....	.....
29.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means.....	1.17	1.12	0.99	0.94	0.90	0.73	0.64	0.58	0.62	0.57	(0.58)
P. M.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.
September 9.....	.....	0.88	0.75	0.65	0.54	0.49	0.46	.....	.....	.....	.....
10.....	.....	1.07	0.91	0.78	0.66	0.57	.....	.....	.....	.....	.....
13.....	.....	1.09	0.98	0.88	0.77	0.67	0.58	.....	.....	.....	.....
14.....	.....	1.19	1.10	1.01	0.91	0.82	0.75	0.69	0.64	0.58	.....
15.....	.....	1.22	1.09	0.98	0.88	0.78	.....	.....	.....	.....	.....
16.....	.....	1.07	0.92	0.85	.....	.....	.....	.....	.....	.....	.....
21.....	.....	1.41	1.33	.....	.....	.....	.....	.....	.....	.....	.....
22.....	.....	1.34	1.24	1.14	1.10	1.06	1.00	0.95	0.91	0.87	.....
23.....	.....	1.22	1.07	0.93	0.82	0.72	0.64	.....	.....	.....	.....
24.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means.....	1.17	1.04	0.90	0.81	0.73	0.69	(0.82)	(0.78)	(0.72)	.....	.....

¹ For a description of exposures of instruments and details of methods of observations, see this REVIEW, December, 1914, 42: 648.

Skylight polarization, measured at solar distance 90° and in his vertical, with the sun at zenith distance 60°, averaged 53 per cent, with a maximum of 72 per cent on the 27th, which is higher than any previous September reading obtained at Washington.

In Table 2, column 2 gives the daily totals of solar and sky radiation received on a horizontal surface at the American University during September, 1915. The measurements were made with a Callendar recording pyrheliometer as described in the REVIEW for March, 1915, 43: 100. Table 2, column 3, gives the daily departures from the normals published in the same number of the REVIEW, page 110, Table 4. An excess of radiation is shown beginning with the 8th.

The "Percentage of possible sunshine," and the "Average cloudiness," given in columns 5 and 6 of Table 3, have been taken from the records of the observatory at the central office of the Weather Bureau. The monthly mean percentage of possible sunshine is 79, as compared with a normal of 60. The decade means are 58, 91, and 87, respectively.

Thus, while the second decade had the maximum percentage of possible sunshine, the third decade shows the maximum excess of radiation, due to the increased intensity of radiation after the 20th of the month.

TABLE 2.—Daily totals and departures of solar and sky radiation at Washington, D. C., during September, 1915.

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.	Departure from normal.	Excess or deficiency since first of month.	Percentage of possible sunshine.	Average cloudiness.
	Gr-cal.	Gr-cal.	Gr-cal.	Per cent.	0-10
September 1.....	362	-54	-54	25	9
2.....	228	-185	-239	2	10
3.....	371	-40	-279	67	8
4.....	352	-56	-335	50	8
5.....	422	16	-319	66	6
6.....	349	-54	-373	50	5
7.....	362	-38	-411	48	6
8.....	438	40	-371	69	4
9.....	480	85	-286	100	1
10.....	431	39	-247	100	1
11.....	474	84	-163	100	0
12.....	445	58	-105	98	0
13.....	464	80	-25	100	0
14.....	485	103	78	100	0
15.....	491	112	190	100	0
16.....	468	92	282	87	2
17.....	445	71	353	95	2
18.....	317	-54	299	49	7
19.....	435	67	366	84	4
20.....	406	39	405	99	3
Decade departure.....	.....	.....	652	.....	.....
21.....	380	17	422	73	5
22.....	538	178	600	100	0
23.....	514	156	756	100	0
24.....	468	113	869	96	1
25.....	365	13	882	100	4
26.....	281	-69	813	53	9
27.....	377	30	843	84	4
28.....	416	72	915	86	4
29.....	458	116	1,031	100	0
30.....	368	29	1,060	81	7
Decade departure.....	.....	.....	655	.....	.....
Excess or deficiency since first of year.....	.....	.....	-1,021	.....	.....

SOLAR RADIATION MEASUREMENTS AT SANTA FE, N. MEX., AND MAXIMA AT OTHER STATIONS.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., Oct. 6, 1915.]

Santa Fe, N. Mex., is at a high elevation in an arid region, and the atmosphere is generally very clear, except that cumulus clouds are apt to form before midday during the warm part of the year and dust storms are not infrequent during the fall months. There is also some smoke from chimneys in the vicinity of the Weather Bureau office, the extent of the disturbance arising therefrom depending upon the wind direction.

The first solar radiation measurements at Santa Fe, N. Mex., were made by the writer in September, 1910, with Smithsonian silver-disk pyrheliometer No. 1. The latitude of the station is $35^{\circ} 41'$ N. and the longitude is $105^{\circ} 57'$ W. The elevation of the pyrheliometer above sea level is 7,013 feet, or 2,138 meters. In October, 1912, a Marvin pyrheliometer of the spiral ribbon type (spiral No. VI) was installed in the Weather Bureau office. A window facing east is the only exposure available for the pyrheliometer, so that radiation measurements are possible during the morning hours only. While installing the apparatus I made measurements from the roof of the building with Smithsonian silver-disk pyrheliometer No. 1 on several afternoons. These measurements, together with those obtained in September, 1910, constitute all the afternoon measurements that have been made at Santa Fe.

Since October, 1912, practically all the observational work has been done by the station force, Mr. C. E. Linney, in charge, and Mr. J. B. Sloan, assistant, the latter making the instrumental readings. The observations have been reduced at Washington, D. C., under my supervision.

Standardization of instruments.—An attempt has been made to standardize Marvin pyrheliometers by measuring the heating effect of an electric current of known strength. As so standardized, however, they have generally given solar radiation measurements a few per cent lower than synchronous measurements by Smithsonian pyrheliometers. The final factors for reducing Marvin pyrheliometer readings to heat units have therefore been determined by comparisons with Smithsonian silver-disk pyrheliometer No. 1. This latter is frequently compared with pyrheliometers in use at the Astrophysical Observatory of the Smithsonian Institution, and no appreciable change in its constants has been detected since its purchase by the Weather Bureau in 1910.

Table 1 gives the results of the comparisons between Smithsonian silver-disk pyrheliometer No. 1 and Marvin spiral No. VI, obtained at Mount Weather, Va., between June 8 and August 24, 1912, from which the reduction factors for the Marvin instrument were first determined. The same table also presents comparisons obtained at Santa Fe on October 26, 1912, a few days after the installation of the Marvin instrument there, and again on April 9 and 11, 1915. The two series of comparisons obtained at Santa Fe indicate that during the intervening period the instrument underwent a change of such a nature as to make the reduction factors originally determined at Mount Weather too large. It is impossible

to determine just when or how this change occurred. It is therefore assumed that it progressed at a uniform rate throughout the interval, and the reduction factors as originally determined have been corrected by multiplying by ratios uniformly interpolated for time between that for October 26, 1912, and the mean of those for April 9 and 11, 1915, given in column 5 of Table 1.

A similar change in Marvin spiral No. 1 was observed at Madison, Wis., between August, 1910, and November, 1911.¹

TABLE 1.—Summary of comparisons of Smithsonian silver-disk pyrheliometer No. 1 and Marvin spiral pyrheliometer No. VI.

Date.	Place.	Smithsonian No. 1.	Marvin No. VI.	Ratio Smithsonian Marvin.
<i>1912.</i>				
June 8.....	Mount Weather.....	<i>Gr.-cal.</i> 1.302	<i>Gr.-cal.</i> 1.324	0.983
June 21.....	Mount Weather.....	1.112	1.150	0.967
July 11.....	Mount Weather.....	0.961	0.964	0.997
August 15.....	Mount Weather.....	0.872	0.871	1.001
August 22.....	Mount Weather.....	0.956	0.956	1.000
August 24.....	Mount Weather.....	0.939	0.937	1.002
August 24.....	Mount Weather.....	0.962	0.953	1.009
October 26.....	Santa Fe.....	1.357	1.376	0.986
<i>1915.</i>				
April 9.....	Santa Fe.....	1.451	1.519	0.955
April 9.....	Santa Fe.....	1.501	1.561	0.962
April 11.....	Santa Fe.....	1.520	1.575	0.965
April 11.....	Santa Fe.....	1.535	1.608	0.955
Mean, April 9-11.....				0.959

Radiation observations.—In Table 5 are summarized all solar radiation measurements made by the Weather Bureau at Santa Fe, N. Mex. An inspection of this table reveals only slight variations in the radiation intensities for a given air mass during any one month as compared with the variations at stations nearer sea level and in a moister climate.

One notes the low radiation intensities obtained between October, 1912, and April, 1913, as compared with the intensities during corresponding months of the following years. The ratio of the mean intensities for October and November, 1912, to the means for the corresponding months of 1914 is 0.86. This is very closely in accord with the deficiency in radiation intensities measured at Mount Weather, Va., and Madison, Wis., and also at other points in the Northern Hemisphere, during these months.²

Table 6 shows the existence of an annual variation in radiation intensities for a given air mass, with a minimum in July and August and a maximum in December. The annual range is about twice as great as would be produced by the annual variation in the earth's solar distance. The monthly means are systematically higher than those published for Madison and Washington in the Bulletin of the Mount Weather Observatory, 1912, 5:182 (Tables 2 and 3), with the exception of the means for January and February for Madison. During the summer months they are from 10 to 15 per cent higher.

¹ Bulletin, Mount Weather Observatory, Washington, 1912, 5:174.² Bulletin, Mount Weather Observatory, Washington, 1914, 6:208, fig. 1; and p. 206, Tables 1 and 2.

TABLE 2.—Monthly maximum noon solar radiation intensities at Santa Fe, lat. 35° 41' N., long. 105° 57' W., altit. 7,013 ft.=2,138 m.; Madison, lat. 43° 05' N., long. 89° 23' W., altit. 974 ft.=297 m.; Mount Weather, lat. 39° 04' N., long. 77° 54' W., altit. 1,740 ft.=530 m.; Washington, lat. 38° 54' N., long. 77° 03' W., altit. 118 ft.=36 m.

[Gram-calories per minute per square centimeter of normal surface.]

(1) MAXIMUM OBSERVED INTENSITIES.

Station.	Month.												Year.	Range.
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.		
Santa Fe, N. Mex.	1.63	1.53	1.59	1.57	1.55	1.51	1.45	1.47	1.53	1.57	1.63	1.58	1.63	0.18
Madison, Wis.	1.49	1.57	1.60	1.58	1.47	1.41	1.36	1.38	1.42	1.38	1.42	1.47	1.60	0.24
Mount Weather, Va.	1.37	1.48	1.48	1.45	1.50	1.47	1.48	1.45	1.50	1.48	1.43	1.40	1.50	0.23
Washington, D. C.	1.42	1.50	1.47	1.49	1.45	1.43	1.47	1.40	1.45	1.45	1.48	1.48	1.50	0.10

(2) MAXIMUM INTENSITIES REDUCED TO MEAN SOLAR DISTANCE.

Santa Fe, N. Mex.	1.58	1.48	1.57	1.59	1.59	1.56	1.50	1.50	1.55	1.56	1.53	1.52	1.59	0.11
Madison, Wis.	1.44	1.54	1.57	1.58	1.50	1.45	1.42	1.41	1.44	1.39	1.40	1.42	1.58	0.19
Mount Weather, Va.	1.32	1.45	1.46	1.46	1.53	1.52	1.53	1.48	1.51	1.47	1.40	1.36	1.54	0.12
Washington, D. C.	1.38	1.47	1.46	1.49	1.49	1.47	1.52	1.43	1.46	1.44	1.46	1.43	1.52	0.14

In Table 2, part (1) gives the highest noon solar radiation intensities that have been measured at Weather Bureau stations, and in part (2) these intensities have been reduced to what they would have been had the earth been at its mean solar distance. The highest measured intensities at Santa Fe are obtained in the fall and early winter, and at Madison and Washington in the late winter and early spring, although at Washington there is little difference between the spring and late fall. At Mount Weather there is no decided maximum, but there is a decided minimum in the early part of winter. At Santa Fe, Madison, and Washington, the minimum occurs in summer.

Reduced to mean solar distance, the maximum noon radiation intensities for Santa Fe show little annual variation. Madison has a decided spring maximum, with a minimum in the fall. At Washington and Mount Weather, the maximum occurs at about the time of the summer solstice, and the minimum at about the time of the winter solstice.

TABLE 3.—Maximum solar radiation intensities corresponding to certain zenith distances of the sun.

[Gram-calories per minute per square centimeter of normal surface.]

Station.	Sun's zenith distance.											
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°	
	Air mass.											
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	
Santa Fe, N. Mex.	1.59	1.67	1.60	1.53	1.41	1.28	1.26	1.16	1.09	1.04	1.00	0.96
Madison, Wis.	1.58	1.61	1.57	1.55	1.47	1.36	1.28	1.18	1.17	1.12	1.07	0.99
Mount Weather, Va.	1.53	1.48	1.43	1.34	1.27	1.20	1.15	1.09	1.04	1.00	0.96	0.96
Washington, D. C.	1.55	1.51	1.51	1.42	1.32	1.24	1.16	1.09	1.04	1.00	0.97	0.97

In Table 3 are given the maximum solar radiation intensities corresponding to certain zenith distances of the sun. At the time of the winter solstice the least solar

zenith distance at Santa Fe exceeds 59°; at Washington and Mount Weather it exceeds 62°; and at Madison 66°. This explains the relatively high radiation intensities at solar zenith distance 66.5° for Madison, 60° for Washington, and 48.3° for Santa Fe. Radiation measurements at lesser zenith distances are obtained at these stations during the warm part of the year only, when the earth is at its maximum solar distance, and the sky contains more dust and moisture than in winter. In the same way, the fact that for zenith distances of the sun exceeding 60° higher radiation intensities have been measured at Madison than at Santa Fe, is to be attributed in part to the exceedingly small amount of dust and moisture in the atmosphere at Madison in winter during the passage of areas of high pressure and low temperature, when the ground is covered with snow. Many more measurements have been made at Madison than at Santa Fe, however.

In general the excess of the maximum radiation intensities measured at Santa Fe as compared with the maxima at low-level stations is much less than the excess shown by a comparison of mean intensities.

On some of the clearest days the radiation intensities for zenithal sun (air mass = 1) reduced to mean solar distance, have been computed by plotting several series of observations as shown in figure 1, and extrapolating to air mass 1. The results are given in Table 4. The winter intensities for Santa Fe and Madison are in close agreement. They fall between values computed by Abbot³ for Mount Wilson and Mount Whitney, Cal. The value computed for Washington on December 26, 1914, equals Abbot's highest value computed from Mount Wilson observations. Those for Mount Weather, which are computed from observations obtained in the warm part of the year, and one for Santa Fe for September 8, 1910, fall considerably below the above.

TABLE 4.—Solar radiation intensities for zenithal sun ($m=1$), and approximate values of the solar constant.

[Gram-calories per minute per square centimeter of normal surface.]

Station.	Date.	Vapor pressure.	Radiation intensity.		Solar constant.
			$m=1$	$m=0$	
Santa Fe, N. Mex.	1910, Sept. 8, P. M.	<i>m. m.</i>	<i>Gr.-cal.</i>	<i>Gr.-cal.</i>	<i>Gr.-cal.</i>
Santa Fe, N. Mex.	1914, Nov. 20, A. M.	7.00	1.57	1.87	2.05
Madison, Wis.	1911, Mar. 4, A. M.	1.55	1.70	1.85	1.93
Madison, Wis.	1912, Feb. 22, A. M.	1.80	1.67	1.89	1.98
Washington, D. C.	1914, Dec. 26, A. M.	1.25	1.67	1.89	1.97
Washington, D. C.	1915, Feb. 28, P. M.	1.15	1.65	1.87	1.94
Mount Weather, Va.	1908, July 16, A. M.	2.00	1.60	1.89	1.98
Mount Weather, Va.	1914, Sept. 28, P. M.	8.00	1.55	1.82	2.02
Mount Weather, Va.	1914, Sept. 28, P. M.	5.00	1.57	1.76	1.90

In figure 1 it has not been practicable to plot the individual readings of each series of observations except when the sun was near the horizon. This is especially the case near mid-day, when the air mass (approximately the secant of the sun's zenith distance) is changing slowly. Hence the plotted points in figure 1 generally represent the mean of from two to eight readings. The nearer to noon the readings were made the greater the number that have been combined into a mean. It is seen that the observations for a given place and day plot very nearly in a straight line, or in a line slightly concave upward. Extending these lines to zero air mass, we obtain the values given in column 5 of Table 4. With the exception of those for Mount Weather, these values ($m=0$) range between 1.85 and 1.89. Following the Smithsonian

³ Abbot, C. G. and others. New evidence on the intensity of solar radiation outside the atmosphere, Washington, 1915 (Smithsonian Misc. coll., 65, No. 4), p. 53.

"Abridged procedure for determining approximately the value of the solar constant."⁴ we obtain from the data of columns 3 and 5, Table 4, the solar constant values given in column 6. These average a little higher than the mean value given by Abbot and others.⁵ We have no assurance, however, that this abridged procedure is applicable to observations obtained at stations whose climatic factors differ from those for Mount Wilson, Cal. Furthermore, the high value obtained from the Santa Fe observations of September 8, 1910, may be attributable to the fact that on that day the vapor pressure increased more than 50 per cent between 6 a. m. and 6 p. m.

zenith distance 60° , they average about 15 per cent higher throughout the year than the monthly means for Washington, D. C., and in summer are about the same per cent higher than the corresponding monthly means for Madison, Wis. In winter and early spring there is little difference between the radiation intensities at Santa Fe and Madison for like zenith distances of the sun.

Likewise, the monthly maximum radiation intensities measured at Santa Fe exceed those at low-level stations, with the exception of the maxima measured at Madison in the late winter and the early spring. The excess is less than half what it is in the case of the mean values, however.

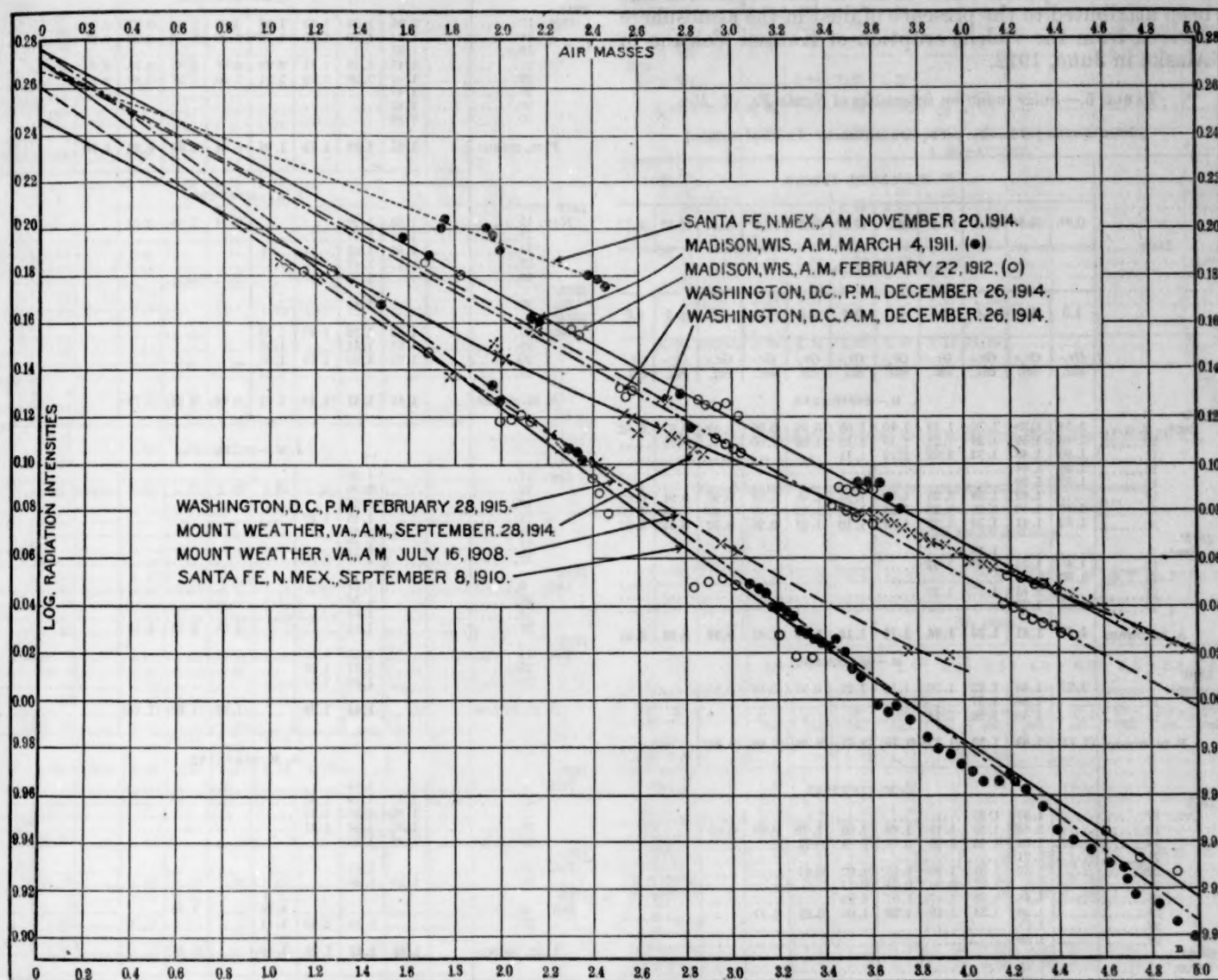


FIGURE 1—Radiation intensities reduced to mean solar distance.

SUMMARY.

Measurements of solar radiation intensity at Santa Fe, N. Mex., show higher monthly means, and much smaller departures from the means, than do measurements obtained at stations nearer sea level. With the sun at

Radiation intensities for zenithal sun with the earth at its mean solar distance—computed from some of the best series of observations that have been obtained at the different stations—give for Santa Fe a radiation intensity of 1.70 calories per minute per square centimeter of normal surface, for Madison 1.67 calories, and for Washington 1.65 calories. A value of 1.55 calories was obtained at Mount Weather in July.

Values of the solar constant computed from these same observations by the Smithsonian "abridged procedure,"

⁴ Annals, Astrophysical Observatory of the Smithsonian Institution, Washington, 1908, 2:115.

⁵ New evidence of the intensity of solar radiation outside the atmosphere. Washington, 1915. (Smithsonian misc. coll. 65:No. 4), page 3.

averaged 1.97 calories, or slightly higher than the mean value given by Abbot.

The relatively high radiation intensities obtained in the late winter and early spring at Madison, Wis., only 297 meters above sea level, are attributed to the local freedom of the atmosphere from moisture and dust during the passage of winter areas of high pressure and low temperature, when the ground is covered with snow.

The radiation intensities measured at Santa Fe during the latter part of 1912 and the early part of 1913 were below the average of following years by about the same amount as has been noted at many other stations in the northern hemisphere. The cause of this depression has been attributed to the presence of dust in the atmosphere derived from the violent eruption of Katmai Volcano in Alaska in June, 1912.

TABLE 5.—Solar radiation intensities at Santa Fe, N. Mex.

(Gram-calories per minute per square centimeter of normal surface.)

Date.		Sun's zenith distance.										
		0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.3°	79.6°	80.7°
		Air mass.										
		1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
		Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
A. M.—SEPTEMBER.												
1910:												
Sept.	9	1.54	1.38	1.30	1.19	1.10	1.05	0.98	0.95	0.89	0.87	0.82
	10	1.49	1.39	1.29	1.21	1.13	1.12	1.06	1.00			
	11	1.56	1.43	1.32	1.22	1.12	1.11					
	13	1.55	1.44									
	17	1.62	1.39									
	18		1.42	1.33	1.25	1.18	1.13	1.06	1.01	0.96	0.91	0.87
	19	1.49	1.40	1.35	1.29	1.24	1.19	1.12	1.09	1.05	1.03	1.00
	20	1.52	1.41	1.32	1.23	1.14	1.10	1.03	0.98	0.92	0.91	0.87
1913:												
Sept.	1			1.13								
	10	1.48	1.36	1.28	1.22							
	13	1.52										
	21		1.45	1.37	1.29							
	29	1.55	1.46									
A. m. means		1.52	1.41	1.30	1.24	1.15	1.12	1.05	1.01	0.96	0.93	0.89
P. M.—SEPTEMBER.												
1910:												
Sept.	8	1.57	1.44	1.32	1.20	1.10	1.01	0.95	0.88	0.83		
	13		1.46	1.37								
	15		1.40	1.26	1.14							
P. m. means		(1.57)	1.43	1.32	(1.17)	(1.10)	(1.01)	(0.95)	(0.88)	(0.83)		
A. M.—OCTOBER.												
1912:												
Oct.	17		1.37	1.25								
	18		1.45	1.33	1.16	1.08	1.05	1.01	0.96	0.92		
	19		1.34	1.23	1.05	0.94	0.84	0.73				
	21		1.21									
	22		1.32	1.31	1.23	1.15	1.07	0.97				
	24			1.07	0.99	0.91	0.77					
	25		1.48	1.30	1.17	1.07	0.99					
	26		1.36	1.33	1.19	1.09	1.00	0.91	0.87			
	28		1.37									
	29		1.38									
1913:												
Oct.	7		1.45									
	8		1.45									
	20		1.47									
	21			1.43								
	23		1.49									
	24		1.46									
1914:												
Oct.	15		1.54	1.47	1.41							
	16		1.55	1.46	1.38							
	17		1.54	1.48								
	27		1.54	1.47	1.40							
	28		1.50	1.47	1.43							
A. m. means			1.44	1.35	1.24	1.04	0.95	0.90	(0.92)	(0.9)		

TABLE 5.—Solar radiation intensities at Santa Fe, N. Mex.—Continued.

Date.		Sun's zenith distance.										
		0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.3°	79.8°	80.7°
		Air mass.										
		1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
		Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
P. M.—OCTOBER.												
1912:												
Oct.	17	1.36	1.23	1.13	1.04	0.95	0.88	0.77	0.74			
	18	1.44	1.30	1.19	1.10	1.00	0.91	0.83	0.76			
	19	1.35										
	21	1.42	1.18	1.11	0.99	0.86	0.80	0.78	0.78			
	22	1.42	1.26	1.18	1.11	1.00	0.94	0.89	0.84			
	25	1.48										
	26	1.42										
	29	1.39										
P. m. means		1.41	1.24	1.15	1.06	0.95	0.88	0.82	0.78			
A. M.—NOVEMBER.												
1912:												
Nov.	12	1.39	1.22			0.94	0.86	0.78				
	13	1.51	1.31									
	14	1.44	1.33									
	22	1.47										
	26	1.28										
1913:												
Nov.	29		1.41									
1914:												
Nov.	12	1.62	1.52	1.43	1.35							
	19	1.61	1.51		1.36							
	20	1.67	1.60	1.53	1.36							
	28				1.17							
A. m. means		1.54	1.41	(1.48)	1.31	(0.94)	(0.86)	(0.78)				
A. M.—DECEMBER.												
1912:												
Dec.	11		1.39									
	12		1.39									
	14		1.53									
	18		1.46	1.29								
	23		1.42									
	27		1.47									
	31		1.39	1.30								
1913:												
Dec.	9		1.51									
	10		1.50									
	13		1.51									
	28		1.51			1.28	1.22	1.16				
1914:												
Dec.	14		1.55	1.44								
	15		1.57	1.50								
	30		1.50	1.44								
A. m. means			1.48	1.39		(1.28)	(1.22)	(1.16)				
A. M.—JANUARY.												
1913:												
Jan.	9		1.46									
	25		1.57	1.39	1.30							
	27		1.40	1.28	1.12							
	28		1.45	1.30	1.11							
	31		1.46	1.38								
1914:												
Jan.	29		1.48									
	30		1.59	1.49								
1915:												
Jan.	8				1.39		1.26					
	27		1.58	1.49	1.41							
A. m. means		1.49	1.42	1.28	(1.40)		(1.26)					
A. M.—FEBRUARY.												
1913:												
Feb.	4	1.55	1.45	1.36								
1914:												
Feb.	13	1.53		1.24	1.13							
	14			1.35								
	20		1.35	1.31	1.27	1.22						
1915:												
Feb.	15	1.53	1.46	1.38								
A. m. means		1.54	1.42	1.33	(1.20)	(1.22)						

TABLE 5.—Solar radiation intensities at Santa Fe, N. Mex.—Continued.

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.3°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
A. M.—MARCH.											
1913: Mar. 10.....	1.33										
15.....	1.48										
16.....	1.40										
28.....	1.39										
31.....	1.41										
1914: Mar. 12.....	1.55	1.46									
13.....	1.54	1.45	1.36								
14.....	1.57	1.45	1.36								
1915: Mar. 24.....	1.56	1.50									
A. m. means.	(1.56)	1.46	1.45	(1.36)							
A. M.—APRIL.											
1913: Apr. 14.....	1.47			1.21	1.13	1.04					
16.....	1.50										
19.....	1.06										
28.....	1.50										
30.....	1.47			1.13	1.04						
1914: Apr. 13.....	1.50										
18.....	1.58	1.47		1.33	1.21						
25.....	1.59	1.48	1.37	1.28							
1915: Apr. 9.....	1.53	1.42									
11.....	1.56	1.49									
20.....	1.36	1.31	1.23								
24.....			1.13								
27.....	1.48	1.36	1.27	1.18	1.10						
29.....			1.29	1.23							
A. m. means.	1.52	1.39	1.32	1.22	1.14	(1.04)					
A. M.—MAY.											
1913: May 12.....	1.49										
15.....	1.49										
17.....	1.47	1.36	1.25	1.16	1.07						
28.....			1.18	1.10							
29.....	1.56	1.45	1.34	1.23	1.13						
31.....	1.47	1.31	1.18								
1914: May 7.....	1.53	1.44	1.34	1.26							
16.....	1.46	1.35	1.22								
26.....	1.53			1.23							
28.....	1.49	1.33	1.27	1.22							
1915: May 22.....	1.50	1.44	1.37								
28.....		1.38	1.32	1.26							
A. m. means.	1.50	1.38	1.27	1.21	(1.10)						
A. M.—JUNE.											
1913: June 30.....	1.54										
1914: June 3.....	1.54	1.43	1.33	1.25							
5.....	1.52	1.42		1.25							
9.....			1.32	1.28							
18.....	1.43	1.32	1.24	1.17	1.11						
22.....			1.37	1.32							
27.....	1.50	1.42	1.35	1.28							
1915: June 6.....			1.36	1.31	1.22						
7.....		1.38	1.27	1.17							
11.....	1.50	1.41	1.32	1.24							
17.....	1.50	1.44	1.38	1.32							
A. m. means.	1.50	1.40	1.33	1.26	(1.16)						

TABLE 5.—Solar radiation intensities at Santa Fe, N. Mex.—Continued.

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.3°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
A. M.—JULY.											
1913: July 1.....	1.47	1.36	1.31	1.18							
7.....	1.43	1.25	1.06								
11.....	1.45	1.31	1.17								
12.....	1.45										
1915: July 31.....		1.40	1.32	1.26							
A. m. means.	1.45	1.33	1.22	(1.22)							
A. M.—AUGUST.											
1913: Aug. 10.....				1.17	1.07						
13.....				1.08							
26.....			1.22	1.14							
27.....				1.13	1.06						
1914: Aug. 7.....	1.40	1.30	1.21	1.11							
14.....	1.46	1.36	1.27	1.20							
24.....		1.35	1.26	1.19	1.11						
25.....		1.35	1.27	1.20							
26.....	1.43	1.31		1.19	1.11	1.04					
27.....	1.49	1.42	1.35	1.29	1.23	1.17					
A. m. means.	1.44	1.35	1.28	1.17	1.12	(1.10)					

TABLE 6.—Monthly means of solar radiation intensity at Santa Fe, N. Mex.

[Gram-calories per minute per square centimeter of normal surface.]

Month.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
A. M.											
January.....	1.49	1.42	1.26	(1.40)							
February.....	1.54	1.42	1.33	(1.20)	(1.22)						
March.....	(1.56)	1.46	1.45	(1.36)							
April.....	1.52	1.39	1.32	1.22	1.14	(1.04)					
May.....	1.50	1.38	1.27	1.21	(1.10)						
June.....	1.50	1.40	1.35	1.28	(1.16)						
July.....	1.45	1.33	1.22	(1.22)							
August.....	1.44	1.35	1.26	1.17	1.12	(1.10)					
September.....	1.52	1.41	1.30	1.24	1.15	1.12	1.05	1.01	0.96	0.93	0.89
October.....	1.44	1.35	1.24	1.04	0.95	0.90	(0.92)	(0.92)			
November.....	1.54	1.41	(1.48)	1.31	(0.94)	(0.86)	(0.78)				
December.....			1.48	1.39		(1.28)	(1.22)	(1.16)			
P. M.											
September.....	(1.57)	1.43	1.32	(1.17)	(1.10)	(1.01)	0.95	(0.88)	(0.83)		
October.....		1.41	1.24	1.15	1.06	0.95	0.88	0.82	0.78		

HALO OBSERVATIONS AT YORK, N. Y.

By MILROY N. STEWART, Cooperative Observer.

[Dated York, Livingston County, N. Y., Sept. 18, 1915.]

The halos recorded in the following tables were observed at York, N. Y. (N. 42° 52' 30"; W. 77° 53'). The usual records of a cooperative observer have been kept since December, 1911, while less complete notes date from three years earlier. The nearest Weather Bureau station is at Rochester, 26 miles to the north-northeast.

TABLE 1.—The numbers of halos observed at York, N. Y., January, 1909, to September, 1915, inclusive.

Year.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total.
A. SOLAR HALOS.													
1909.....	1	2	2	6	4	4	3	1	1	3	0	0	27
1910.....	2	4	2	0	4	3	0	0	3	2	2	3	25
1911.....	1	3	6	5	5	3	3	4	2	5	0	2	39
1912.....	7	2	12	6	5	4	4	2	6	6	3	3	60
1913.....	9	6	6	4	6	3	6	6	6	8	4	2	66
1914.....	4	10	8	3	3	5	5	5	6	2	6	4	61
1915.....	7	2	2	2	2	7	9	7	8	.....	.....	.....	[47]
Totals....	31	29	38	27	29	29	30	25	32	26	15	14	325
Means....	4.4	4.1	5.4	3.8	4.1	4.1	4.3	3.6	4.6	4.3	2.5	2.3	.....
Smoothed means ¹	4.1	4.5	4.7	4.2	4.0	4.1	4.1	3.9	4.3	3.8	2.9	2.9	.....
B. LUNAR HALOS.													
1909.....	1	0	0	3	0	1	0	0	1	0	3	1	10
1910.....	1	2	0	0	1	0	0	0	0	1	0	3	8
1911.....	3	2	3	0	0	0	0	0	0	1	1	1	11
1912.....	0	1	1	0	0	0	0	0	0	2	3	2	9
1913.....	2	0	0	0	3	0	1	0	0	0	1	1	8
1914.....	1	0	3	0	1	0	0	1	0	0	1	2	9
1915.....	1	0	2	1	1	0	0	1	3	.....	.....	.....	[9]
Totals....	9	5	9	4	6	1	1	2	4	4	9	10	64
Means....	1.3	0.7	1.3	0.6	0.9	0.1	0.1	0.3	0.6	0.6	1.3	1.6	.....
Smoothed means ¹	1.2	1.0	1.0	0.8	0.6	0.3	0.15	0.2	0.5	0.65	1.2	1.4	.....

¹ E. g., January = $\frac{\text{Dec.} + 2 \text{ Jan.} + \text{Feb.}}{4}$

Table 1 includes all halos noted and shows their relative monthly frequency. It is quite evident that many displays must have been missed during 1909, 1910, and 1911. Owing to the deficiency of the records for those years the computations of the time elapsing between halos and succeeding precipitation are based chiefly upon the observations of the last three and a half years.

It is a source of regret to the writer that unfamiliarity with practical methods has prevented angular measurements of the individual phenomena.

Table 2 is designed to bring out the frequency with which the halos were followed by precipitation, and the length of time before such precipitation usually occurred. The results seem less uniform—with regard to seasonal effects—than those obtained at Blue Hill. A similar March maximum is found, but the minimum occurs in December rather than in October. The normal length of time elapsing before precipitation (20.5 hours) is quite a bit in excess of that at Blue Hill (15.6 hours). Lunar halos have been omitted from Table 2, but a study of 55 shows that 46 (83 per cent) were followed by rain or snow before the end of the second succeeding day. In the case of these halos the precipitation appears to follow more quickly—the average interval being 17.3 hours.

It is noted that halos which are not followed by precipitation often occur in succession. Those on Septem-

ber 10, 11, 14, 18 and 20, 1914, are examples. Indeed at this station 37 per cent of all observed September halos have been succeeded by more than two days of fair weather.

TABLE 2.—Relations of occurrence of solar halos to occurrence of precipitation at York, N. Y., from December, 1908, to September, 1915.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals and means.
SOLAR HALOS.													
Total number considered.....	31	29	38	27	29	29	30	25	24	26	15	14	317
Percentage followed by precipitation on same day.....	13	31	39	22	10	24	23	20	19	27	33	21	23.5
Percentage followed by precipitation on first succeeding day.....	61	62	74	66	76	41	73	83	53	38	73	64	64.0
Percentage followed by precipitation on second succeeding day.....	58	65	54	44	51	48	70	56	40	31	66	64	53.9
Average number of hours between halo and precipitation.....	21.4	13.7	20.2	19.3	20.7	21.2	26.5	19.5	19.6	22.6	18.6	22.0	20.4
Percentage not followed by precipitation by end of second succeeding day.....	19	14	11	15	7	27	7	12	37	27	13	14	17
Average hour of occurrence (first seen).....	12.1	12.4	12.5	11.7	11.9	12.2	8.7	12.9	11.7	11.7	12.4	11.8	11.7

The wind direction, at the times halos have been noted, has been prevailing south with the exception of the month of December when it has been southwest.

Unusual displays at York, N. Y.—By far the greater number of recorded displays consisted merely of the 22°-halo—often with accompanying parhelia, especially in the late afternoon. A few times more complex phenomena were seen. On March 14, 1912, concentric halos of 22° and 46° became visible at about 7:30 a. m. Both showed red on the side toward the sun. The colors of the outer circle were the more distinct.

The inner halo was much brighter through an arc of about 35° on its upper (west) side and parhelia were visible. The north side of the whole display was the brightest because the clouds were thickening on the south. At the uppermost point of the 46°-halo there was, tangent to it, what appeared to be an arc of a circle of about 22°. This was brilliantly colored with the red on its convex side. Green was the color most in evidence. This tangent arc increased in brilliancy until 8:20 a. m., when it began to fade and was followed 10 minutes later by the 46°-halo. The 22°-halo lasted to about 10 a. m. There was (8 a. m.) a white spot in the north at an altitude above the horizon equal to that of the sun, and of the size of a parhelion. The temperature was about 20°F., wind south. Snow, changing to rain, began during the following night, and 0.55 inch had fallen by 2 p. m. on the 15th.

April 4, 1912, at 4:30 p. m., the circumzenithal arc was seen. Red, blue, and green could be distinguished. Temperature, 38°F.; wind, SW. The barometer fell 0.45 inch during the next 24 hours, but no precipitation more than a trace occurred till the 7th.

On February 9, 1914, at 9 a. m., there was a faint 22°-halo with parhelia. The circumzenithal arc was visible, showing red and blue-green. Temperature, 10°F.; wind, W. A light snowfall followed in 26 hours. On February 13, there was a display similar to that on the 9th, but occurring at 2:45 p. m. The 22°-halo had been visible in the forenoon, with its highest and lowest parts especially bright. Temperature, 15°F.; wind, NE. A snowfall amounting to 10.5 inches began at 6 p. m.—only three hours later.

On January 16, 1915, at noon, a 22°-halo was observed. At 12:20 p. m., an arc appeared about 46° above the sun, having the colors of the circumzenithal arc, but apparently concave toward the sun. At the same time the upper portion of the 22°-halo became brighter, and assumed the form indicated in figure 2. The east parheliion made its appearance at about 1:20 p. m. There was an intensely bright, white area just at and above the juncture of the 22°-halo and its tangent arcs. The colored arc faded at 1:45 p. m.; the upper part of the 22°-halo was still visible at 3:30, but disappeared soon after. Temperature, 35°F.; wind, S. Rain began after an interval of 17 hours and fell on the nine succeeding days.

CUMULUS OVER A FIRE.

By EDW. N. MUNNS.

[Dated Converse Experiment Station, Redlands, Cal., Aug. 5, 1915.]

During a brush fire on August 5, 1915, a cumulus cloud developed at the head of the smoke. The cloud appeared first at 3:05 p. m., lasting 20 minutes. It reappeared at 4:55 p. m., and lasted 12 minutes. The cloud was a typical cumulus, and formed close to 1,000 feet above the fire area.

ELECTRICITY OF ATMOSPHERIC PRECIPITATION.¹

By G. C. SIMPSON.

[Reprinted from Science Abstracts, Sec. A, Sept. 25, 1915, § 1305.]

While there are still certain questions relating to the electrical state of precipitation which have not been answered definitely, the broad features are now generally agreed upon by all observers. To account for these features two theories have been put forward: (a) The influence theory of Elster and Geitel; and (b) Simpson's "breaking drop" theory. In the present paper these two theories are considered, particularly with reference to the manner in which they will explain the observed facts. Elster and Geitel's influence theory (a) is based upon the idea that small water drops can come into electrical contact with large ones without uniting with them. Simpson considers that this supposition is far from established, and further suggests that even if sound it will not satisfactorily account for the electrical phenomena observed during rain. When the breaking-drop theory (b) was first put forward, evidence was adduced to show that it fully accounted for the electrical phenomena found with thunderstorms, but nonthunderstorm rain and snow were not so fully dealt with. There has been some doubt as to whether breaking of drops does actually occur with ordinary steady rain, and without such breaking the theory fails. Evidence is brought forward to show that such breaking of large drops into small ones does occur in a gusty wind and will probably occur also to some extent in a still atmosphere, and this being granted, it is found that the theory will satisfactorily account for the changes of potential gradient which occur near the ground during rain in addition to explaining the charge on the rain itself. With regard to snow, it is suggested that the rubbing together of the flakes will produce electrification in the same way that Rudge has found electrification to be produced in

dust clouds, and this action will correspond with the breaking of drops in the case of rain.²—J. S. Dines.

AURORA OBSERVATIONS IN 1913.³

By C. STÖRMER.

[Reprinted from Science Abstracts, Sec. A, Sept. 25, 1915, § 1236.]

Although only a part of the material obtained on the expedition to Bossekop in 1913 has been worked up, the author has now details of about 600 very exact measurements of the altitude of the aurora and of its positions in space, all determined from photographs taken simultaneously from the two stations, Bossekop and Store Korsnes, lying about 27.5 kilometers from each other in a north and south line, and connected by telephone for direction of the observations. A notable result is the consistency with which the lower limit of altitude for the auroras is found to be from 90 to 100 kilometers.

The pictures of the auroral draperies on March 11-12, 1913, have been examined for the purpose of determining the nature of the discharge. For this magnetograms for the same epoch were obtained from the observatory at Haldde, about 13 kilometers west of Bossekop. Marked perturbations were visible on the magnetograms, showing that the magnetic action was so directed that it had components pointing to the north, west, and upward. Assuming that the electric corpuscles descend into the atmosphere from without, along the magnetic lines of force, forming auroral rays which combine to form the drapery, we can find by a simple application of Ampère's law that it seems to be proved that the aurora was caused by positively-charged electric particles. Diagrams are given in illustration of this view.—C. P. Butler.

THE GREAT AURORA OF JUNE 16, 1915.⁴

By E. E. BARNARD.

[Reprinted from Science Abstracts, Sec. A, Sept. 25, 1915, § 1235.]

A very remarkable exhibition of auroral activity was observed at the Yerkes Observatory on the night of June 16, 1915. Starting in the form of a strong low-lying arch without streamers, the activity gradually increased until the brilliant glow reached the pole, the lower portions being broken with bright moving masses and the upper part being double. After dying down, the phenomenon was repeated some hours later, and then the arch structure gave place to long ascending streamers, quick waves of auroral light rising to the zenith with remarkable rapidity. These continued for over an hour until further observation was interrupted by dawn. The maximum intensity occurred about 8:15 a. m., G. M. T., on June 17. A few of the brightest masses could be detected 20 minutes after dawn. There was little color in the display at any time, although a few of the streamers gave indications of a pink tinge. Photographs of the sky taken during the display were found to be badly fogged by the auroral light, which seemed to be more actinic than moonlight.

Widespread effects on telegraph systems appear to have occurred at the same time as the aurora. On the other hand wireless signals appear to have been normal throughout the period of the maximum display.—C. P. Butler.

¹ A summary of Simpson's previous conclusions will be found in this REVIEW, June, 1914, 42: 348.—C. A., Jr.

² Terrestrial Magnetism, March, 1915, 20: 1-12.

³ See Nature (London), July 15, 1915, 95: 536-537.

⁴ See Phil. Mag., London, July, 1915, 29: 1-12.

SECTION II.—GENERAL METEOROLOGY

A REMARKABLE FALL OF HAIL IN MARYLAND.

By OLIVER L. FASSIG, Professor of Meteorology.

[Dated: Weather Bureau, Baltimore, Md., Sept. 4, 1915.]

First accounts of hailstones of unusual size are apt to be exaggerated. When the daily papers published reports of a severe local storm which passed over central Maryland in the afternoon of June 22, 1915, accompanied by hail as large as a baseball or an orange, the writer was inclined to make further investigation before accepting the statement literally, although some of the accounts were accompanied by measurements and detailed descriptions. Brief inquiry among the residents of Annapolis, where the largest stones appear to have fallen, showed however, not only unusual accuracy in the first reports, but revealed the remarkable fact that the first newspaper reports actually failed to give a sufficiently vivid account of this phenomenal storm.

Path of storm.—The fall of hail was apparently confined to central and northern Maryland and to Delaware, although thunderstorms prevailed over a much greater area, extending into neighboring States on the north.

Reports indicate that the hail began about 1:30 p. m. in the western portion of Carroll County, Md., and that the storm moved southeastward across Howard and Anne

Arundel Counties, crossed Chesapeake Bay into Talbot, Dorchester, and Wicomico Counties. It probably passed over the Atlantic, through Worcester County, at about 5 p. m. The hail was particularly destructive to crops and exposed windows within the narrow belt, probably less than 5 miles wide, extending from Union Bridge along the southwest border of Carroll County, through Sykesville, Woodstock, Ellicott City, Annapolis, Claiborne, and Oxford. (See fig. 1.)

Judging from the size of the hailstones alone, the storm seems to have attained its maximum intensity between 2:30 p. m. and 3 p. m., as it passed over the city of Annapolis, although the stones were almost as large, apparently, near Woodstock and Ellicott City, in Howard County, and at Claiborne, across the Bay from Annapolis, in Talbot County.

Other storms of the day.—Hail, although not of unusual size, was reported from a number of localities to the north of the path followed by the storm described above, namely, Darlington in Harford County, and Sudlersville in Queen Anne's County, Md., and Millsboro in Sussex County, Del. These towns are located along a line parallel with the path described and the storms probably belong to another series, as they occurred about an hour later in the afternoon.

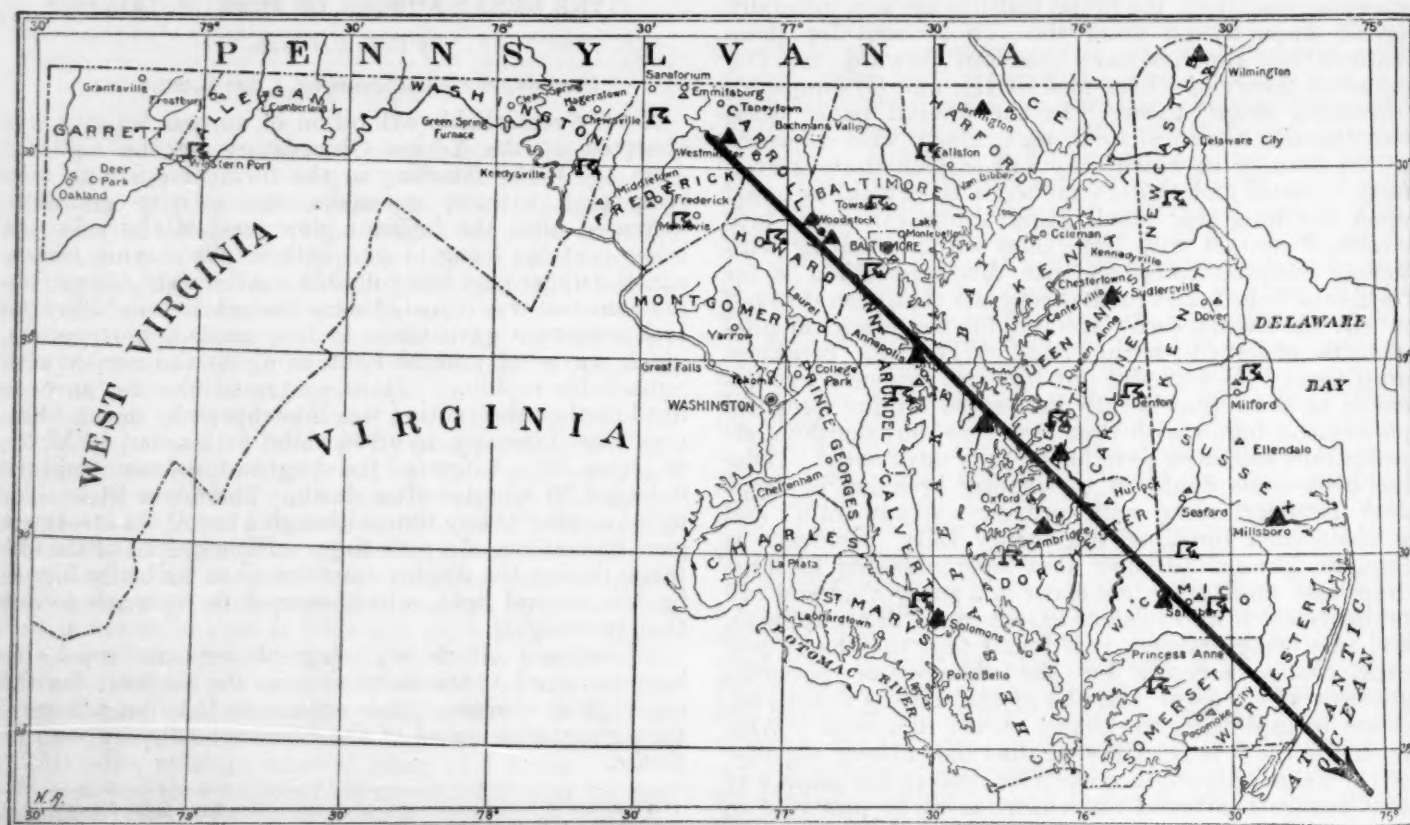


FIG. 1.—The path of the hailstorm of June 22, 1915, across Maryland and Delaware.
▲, localities reporting hail; □, localities reporting thunderstorms.

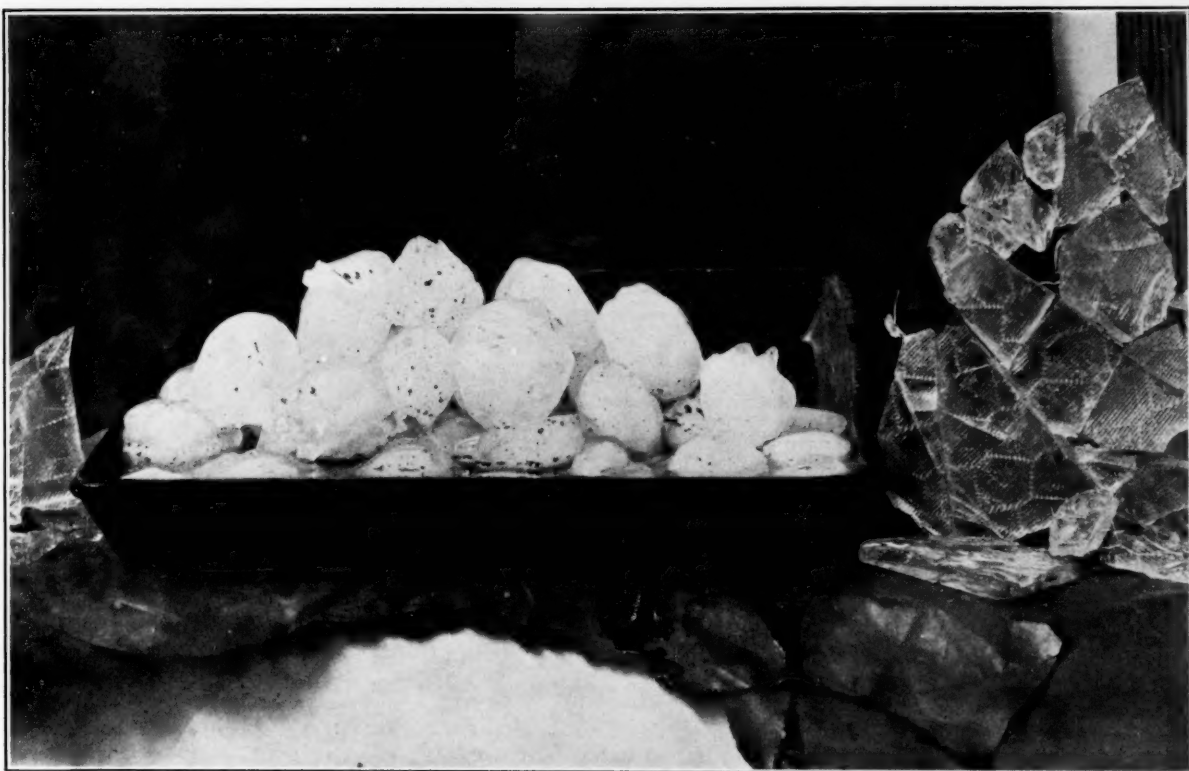


FIG. 2.—Hailstones gathered at the experiment station of the U. S. Naval Academy, Annapolis, Md., June 22, 1915. (Bottom of tray containing hailstones is 10½ inches long.) Average dimensions of 10 selected stones were 3½ by 3 inches; maximum diameter of the largest measured stone was 3½ inches. Wired-glass fragments, ⅝ inch thick, from the shattered skylights of the Academy buildings.

Size of hailstones.—The hailstones were of a size never before seen in this vicinity. The large ones were generally referred to as being the size of a baseball or an orange. Numerous measurements of individual hailstones were reported. Among the most reliable known to the writer are those made by two officials of the United States Naval Academy. Ten or twelve stones, accurately measured, gave an average diameter of $3\frac{1}{4} \times 3$ inches, with a maximum major diameter of $3\frac{1}{2}$ inches. In another series of measurements the largest stones exceeded 4 inches in diameter. These measurements are equivalent to a circumference ranging from 10 to 12 inches. Reports from observers in other localities are in harmony with these figures. A hailstone picked up at Ellicott City measured $9\frac{1}{2}$ inches in circumference.

Stones the size of a baseball (i. e., 9 in. or 228.6 mm. in circumference) were not at all uncommon along the path of the storm from Woodstock to Claiborne. All accounts of observers at Annapolis agree that the ground there was never covered with hail, and that the larger stones were probably never more numerous than 8 or 10 to the square yard (0.84 sq. m.).

Weight of hailstones.—Statistics as to the weight of individual stones are less numerous. Information available is to the effect that "they averaged from 3 to 4 ounces"; that "they ran about 5 to the pound"; that "3 of them weighed a pound"; and "that some weighed 6 to 7 ounces, while stones 4 to the pound were not uncommon". The circumference of a league baseball measures 9 inches, and its weight is 5 ounces; hence the comparison commonly made holds both as to weight and size.

Structure and shape.—The structure of the hail was similar to that usually met with, namely, a nucleus of snow or opaque ice, with concentric shells of alternately transparent and opaque ice. In some of the larger stones from 20 to 25 such layers were counted.

There was also the usual diversity in shape. Some stones were nearly spherical; some spheroidal, prolate, and oblate; some disk-shaped; some top-shaped. Some resembled a small cymling,¹ some were with prongs or knobs, and some without.

Damage done.—It is rather remarkable that such a shower of stones lasting from 15 to 20 minutes and passing over a city with a population of approximately 10,000 should have caused so little personal injury. The writer heard of only two men who received scalp wounds of sufficient severity to require hospital treatment. Injuries to horses were numerous. According to reports, one horse had the good judgment to take refuge in a near-by grocery store.

The force of the impact of hailstones may be gaged quite accurately from the destruction wrought in the glass roofs of the Naval Academy buildings. About half of the panes of glass in the skylight of the gymnasium, between 400 and 500 in number, had to be replaced; the glass was fully half an inch (1 cm.) in thickness. The skylights in the roof of the main building of the experiment station, across the Severn, contained glass $\frac{5}{8}$ inch thick with embedded wire netting. The accompanying photograph, figure 2, shows a tray filled with some of the larger hailstones gathered near the experiment station. To the right and left of the tray are shown fragments of the wire-glass shattered by the hail. The irregular and

spiked outline of some of the stones is clearly indicated in the picture.

The following interesting accounts of the storm and of the remarkable hailstones, are taken from letters received from Rev. J. F. Dawson, S. J., of Woodstock College, a cooperative observer of the Weather Bureau, and from Mr. F. S. Bullard, of Annapolis, who is connected with the experiment station of the Naval Academy:

The hailstorm of June 22, 1915, seemed to develop a few miles north or northwest of Sykesville; some place between Sykesville and Westminster. It was very violent near Eldersburg, on the Liberty Road, and on two farms in that neighborhood practically the whole crop was destroyed. The stones in that region were smaller than at Woodstock and cut the corn to pieces. With us the damage was done by breaking off the smaller stalks. The storm moved toward the southeast, the center crossing the Baltimore & Ohio Railroad near Gorsuch station, about 3 miles east of Sykesville. The center passed a little to the west and south of us, and along the line of its passage the stones seemed to be smaller than at the college. I am inclined to think that it went a little south of Ellicott City and north of Laurel, but am not sure.

With us the stones were not spherical, but were ellipsoids, nearly all prolate, but quite a number oblate. The larger were composed of fully 20 or 25 layers, alternately clear ice and white snow ice. Generally the nucleus was composed of white softer ice. I never saw any that equaled them in size. The measurements I sent you ($2\frac{1}{2}$ inches) were not those of the very largest, but were taken from stones that were numerous.—J. F. Dawson, S. J., Woodstock College.

The hailstone picture I sent you was taken by Mrs. Bullard. She weighed several of them and they ran about five to the pound.

I was at the experiment station [of the Naval Academy]. The hailstones were much larger, and there were more of them, on that side of the [Severn] river. I measured several that were over 4 inches in diameter. A very interesting feature was their peculiar shape, being covered all over with knobs or horns; others were pear-shaped, while still others were wedge-shaped, with rounded top. Some of the larger ones had snow inside.

A few of the larger stones crashed through our skylight like a cannon ball and fell to the floor unbroken. The smaller ones just shattered the glass, which was $\frac{1}{4}$ inch in [thickness] and reinforced with wire.

The storm lasted from 15 to 20 minutes. The spectacle on the water was very weird and interesting. The splashes of the falling hailstones rose 3 or 4 feet, and there were so many of them that it looked as if the river rose right up. The hail was so thick that you could not see across the river.

I inclose a small piece of the broken skylight. The damage at the experiment station was about \$3,500.—F. S. Bullard, U. S. Naval Academy Experiment Station, Annapolis, Md.

An interesting but unconfirmed account stated that small pebbles were found at the center of some of the larger hail gathered at Annapolis. The young man who related the story offered to produce the pebbles, but has not yet done so.² The observer was doubtless sincere in his belief that the pebbles were in the hail as it fell, but as the hailstones in question were apparently gathered in the street, it is probable that the pebbles were picked up when the hail struck the ground, and that they were too deeply embedded to be noticed until the hailstones melted. Until a more accurate account is at hand of the circumstances under which the hail was gathered and melted, the story must be classed with the numerous rumors which may be labeled "important—if true."

Previous accounts.—The literature of hailstorms contains references to stones of larger size than those gathered at Annapolis on June 22, 1915, but such instances are rare and, so far as the writer is aware, confined to foreign lands. Dr. von Hann, in the latest edition of his "Handbuch der Meteorologie," cites occurrences of hailstones measuring from 4 to 6 inches in diameter and weighing over a pound. We frequently read about hail of much greater size, but such reports, upon investigation, generally prove to be exaggerations; sometimes they refer

¹ *Cymling*, the scalloped "pattypan" or summer squash (*Cucurbita pepo*, var. *condensa*), also spelled "simlin."
The Century Dictionary says: "Simnel. . . . 2. A variety of squash having a round flattish head with a wavy or scalloped edge and so resembling the cake [or simnel]: now called simlin."

² Since writing this the author states he has received some of these pebbles.

to a cluster of individual stones which froze together while falling or after reaching the ground.

India seems to be a land of frequent occurrence of hail of unusual size. Eliot, in a study of Indian hailstorms, tabulated measurements of the hailstones of 600 storms, and found that in 27 per cent of the measurements the stones were smaller than peas; in 51 per cent they were larger than peas, but smaller than a lemon; in 22 per cent they were larger than a lemon. Another investigator, Bruist, found the *mean maximum circumference* of Indian hailstones to be from 4 to 6 inches, with a weight varying from 2.2 to 4.4 ounces. The largest were 10 to 13 inches in circumference, weighing from 0.62 to 1.24 pounds.

In the light of recent knowledge of the temperature conditions existing in the upper atmosphere and of the general weather conditions which accompany severe local disturbances, such as tornadoes, thunderstorms, and hailstorms, it is not a difficult matter to account for the production of hail during the warm months of the year. But the manner in which masses of ice are sustained in the atmosphere long enough to acquire a weight of many ounces is still something of a mystery. However, we

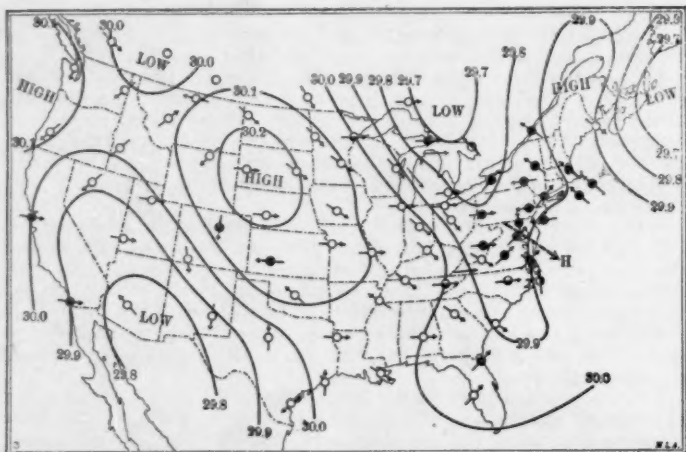


FIG. 3.—General weather conditions at 8 a. m., June 22, 1915. The hailstorm occurred six hours later along the dotted line, *H*, across Maryland.

know that hailstorms exhibit evidences of rapid and powerful rising currents within the central cloud masses; that there is generally an incessant play of lightning between the clouds, and that these clouds are built up to great heights, retaining the liquid character of their particles in a subcooled condition with temperatures far below freezing. Volta long ago accounted for the onion-like structure of hailstones by assuming that the hail nucleus, once formed, is kept in a state of oscillation between oppositely electrified clouds until the constant accretion of layers of ice so increases the weight that the hailstone can be no longer sustained by the movements of the atmosphere, and falls to the ground. Variations in the electrical potential of cloud particles are known to cause the particles to coalesce. Ferrel suggested that the strong ascensional currents within a hailstorm carried the hailstones to great heights, receiving constant accretions on their way, and that it is probable that the hail, falling out of the strong ascensional currents or being thrown out, may be repeatedly carried up to altitudes where the temperature is below freezing and thus grow to great size before falling to the ground.

General weather conditions.—The 8 a. m. weather map of June 22, 1915, showed a general condition very favor-

able for the formation of severe local storms. (See fig. 3). A well-developed and extensive area of high pressure was moving rapidly eastward across the Central States. There was a narrow ridge of relatively high pressure over the New England States and extending southward over the Atlantic Ocean. The Lower Lake Region, the Middle and the South Atlantic States, were in a trough of low pressure, with a sharply defined "squall line" separating the southerly and easterly winds and overcast skies from the strong westerly winds and clear skies. The V-shaped depression was moving from southwest to northeast across the Middle Atlantic States; the local thunderstorms and hailstorms which formed along the advancing front of the area of high pressure, or along the squall line, moved southeastward across Maryland and Delaware at the rate of approximately 50 miles per hour.

At Baltimore the barometer fell steadily from midnight of June 21 to nearly 5 p. m. of the 22d, when it rose abruptly 0.05 inch. This jump was accompanied by a change in the direction of the wind from southerly to northerly, marking the passing of the "squall line." Earlier on the 22d, between 1:30 p. m. and 2 p. m., a thunderstorm was observed west of the city moving from northwest to southeast. Undoubtedly this was the storm which produced the heavy fall of hail at intervals along the path from Carroll County to the Atlantic Ocean.

INFLUENCE OF A FOREST ON THE TEMPERATURE OF AN AIR CURRENT.¹

L'abbé MICHEL LALIN.

[Dated: Vieigne (Côte-d'Or), Mar. 26, 1913.]

* * * My observations are here confined to the single problem of what influence a wooded region may exert on the temperature of a current of air.

The forest of Four (Bois du Four) between Spoy and Vieigne in the Côte-d'Or has a width of about 800 meters. Two thermometers, graduated to one-tenth degree [centigrade] were set up on the eastern and western margins at a distance of about 30 meters from the wood. At each observation their readings were checked against the reading of a whirled thermometer.

Between May 15 and September 30 I made 70 observations at various hours but most often in the forenoon. The results are as follows:

EAST wind, 17 times: On the E. margin the thermometer always showed readings 0.3° to 0.8°C. *higher* than those on the W. margin.

WEST wind, 26 times: The thermometer on the E. or downstream from the wood showed readings 0.3° to 0.75°C. *lower* than those on the W. margin.

RAIN, 8 times: Wind was W. or SW., but the temperature was the same on either margin of the wood.²

CALMS or the wind did not blow across the wood from one station to the other, 19 times: The thermometers were in accord.

I conclude that the current of air has cooled in passing through this thin tree-curtain.

On examining the figures it seems to me that one is led to conclude that this modification in temperature is quite independent of the initial temperature of the air and depends solely on the velocity of the wind. The lighter the wind, the greater is the difference. The maximum difference of 0.8°C. corresponded with a wind of velocity 3 on

¹ Assoc. Franc. pour l'Av. des. sci., Compte rendu de la 42me sess. Tunis, 1913: Notes et Mémoires, Paris, 1914, pp. 242-243.

² This is readily explained as the result of the lower calorific capacity of water.—*Author*.

the [French] telegraphic scale [i. e., 4 to 6 m/sec., or about 12 miles an hour].

Mixture with layers of warmer air upon emerging from the wood, rapidly decreases this difference.

It may be asked here, whether this fall in temperature has any influence on atmospheric precipitation. On August 2, with a wind WSW., the west side of the wood was quite immune, but the whole east side was watered by a fine rain that extended almost 2 kilometers out from the eastern margin. At Vieville, about 1 kilometer distant, the rain-gage collected 1.4 millimeters of rain. I must admit that this is the only observation that was checked up, although the rainy summer [of 1913] did not lack in other opportunities. However, on several occasions when noticing the road that traverses this little grove from east to west, I have observed that all that portion stretching in front of the wood (east) was moistened, while behind the wood (west) there was no trace of rain.

COMMENT.

The above note by M. Lalin formulates an interesting problem to the forester-meteorologist. The effort to solve the problem experimentally may have been as successful as is stated; but the author does not tell us anything about a most important detail, viz, the conditions under which he exposed his thermometers. As is well known, and was recently emphasized again (this REVIEW, August, 1915, pp. 389-390), the usual French screen does not permit us to compare temperatures within such narrow limits as 0.3 or 0.8 degree centigrade difference in readings. The American meteorologist will therefore reserve judgment on both the temperature influence and the rainfall believed to have been produced by this restricted wood.—C. A., jr.

ORGANIZATION OF THE METEOROLOGICAL OFFICE IN LONDON.¹

By W. N. SHAW, Director.

[Dated: London, S. W., Dec. 22, 1914.]

His excellency asked to be informed of the "*textes législatifs et administratifs* qui réglementent les services de météorologie générale et plus particulièrement de météorologie agricole en Grande Bretagne."

Textes législatifs.—The only legislative authority for the meteorological services of this country in any year is the appropriation by Parliament of a sum as a "Grant-in-Aid" for the "Meteorological Office" in the appropriation act of that year.

A "Grant-in-aid" is a fixed sum handed over by His Majesty's Treasury to be administered under conditions laid down by the Treasury, by some body of persons, whether constituted expressly for that purpose or not, who become responsible for the expenditure and for any administrative action taken in conformity with the prescribed conditions.

The Ministers responsible to Parliament for the grant, the Lords of the Treasury, accept no responsibility for the actions of the administrative body provided they are within the prescribed conditions.

¹ Reprinted from Tenth Annual Report of the Meteorological Committee * * * for the year ended 31 March, 1915 (the 60th year of the Meteorological Office). London, 1915, pp. 65-74.

This memorandum was "drawn up * * * at the request of the Foreign Office, dated 2d February, 1914, for the use of the French Ambassador [to Great Britain]."

The grant for the expenses of the Meteorological Office was fixed at £20,000 [\$97,330] in the year 1913. It is included in the Votes for Scientific Investigations, and is made to the Meteorological Committee, a body constituted by a Minute of the Treasury.

By custom, the committee which administers a grant-in-aid is allowed to undertake the administration of other grants, and also to receive payment for special duties undertaken for, or in certain cases, to departments of Government. It is not entitled to the official services of the Post Office or other departments of state, but by special arrangement the Meteorological Office enjoys certain official facilities with regard to the priority of meteorological telegrams and with regard to stationery and printing.

The total expenditure on the various services in the administration of the Meteorological Committee is about £30,000 [\$145,995] a year. It must, however, be pointed out that the meteorological observations available at the office include those which are carried on by municipal corporations and by private persons primarily for their own purposes and at their own expense. The office acts only as adviser, organizer, compiler, and publisher of results in these cases. This voluntary work—taking observations of rainfall also into account—probably represents an expenditure of £20,000 [\$97,330], making the whole expenditure on meteorological services in [Great Britain and Ireland], including municipal and private enterprise, about £50,000 [\$243,325], of which £21,000 [\$102,196] is provided by Government.

Textes administratifs.—The only *textes administratifs* for the meteorological services are the Minute of the Lords Commissioners of His Majesty's Treasury, dated 20th May, 1905, constituting a Director of the Meteorological Office and a Meteorological Committee with the Director as chairman, and subsequent Treasury Minutes reconstituting the committee or appointing members thereof. * * *

In accordance with regulation, accounts of the receipts and expenditure of the office for each year are audited by the Comptroller and Auditor General and reported to Parliament. A report upon the work of the office is presented each year to the Treasury and laid before Parliament by command of His Majesty.

Any member of Parliament is therefore at liberty to raise any question upon the accounts or the report, but otherwise, with the limitations herein indicated, the director and committee have full discretion as to the objects to which the funds shall be devoted and the means which shall be adopted for securing them.

The practice of the Office is guided by tradition which has been formed in the past 60 years. The grant-in-aid has been increased from time to time for reasons urged either by the controlling authority or by parliamentary critics of the Office. Each increase has carried with it the intention to accomplish some specific object, and therefore, a tacit obligation on the part of the controlling authority; but the Treasury has never made conditions about details of expenditure and has always accepted the statement of the proposed allocation of the grant without comment, so that the Committee is not bound by any conditions but merely guided by its own judgment in accordance with tradition and practice.

It is important to note this in consideration of the special application of meteorology to agriculture. That is one of the objects of the Office, but any other of the applications of meteorology in the interest of the public is equally so. There is no special allocation of funds for the application of meteorology to agriculture as such.

GUIDING PRINCIPLES OF THE METEOROLOGICAL OFFICE.

The operations of the Meteorological Office being guided so largely by tradition and practice, without any *textes administratifs* which prescribe its duties and operations in detail, the only means of obtaining a conspectus of the guiding principles of its organization is by reference to the annual reports which have been issued since 1868, to occasional reports before that date and to the reports of certain Committees of Inquiry, from which the present organization has grown. It now comprises a central office with 4 technical divisions, 2 branch offices, 6 meteorological observatories, about 30 subsidized stations and upward of 300 voluntary stations. Terrestrial magnetism and seismology are associated with meteorology. The reports are, however, so voluminous that the following brief historical retrospect may be acceptable. It is necessary to go into some detail because the subject ultimately under consideration is the application of meteorology to agriculture, and in such a case application means that the agriculturist must be in a position to receive and use the information which the meteorologist has to give. This requires much preliminary work, first, to put the meteorologist in possession of the necessary facts and principles, and secondly, to enable the agriculturist to understand the technical language and ideas without which communication is meaningless.

Marine meteorology.

1. The Meteorological Office was started in 1854 under Admiral R. FitzRoy as the meteorological department of the Board of Trade, and on the recommendation of an International Maritime Conference held at Brussels in 1853. The sole purpose of the department was the supply of meteorological instruments to the navy and mercantile marine, and the collection and discussion of meteorological observations from ships.

Those duties still remain in much the same form. They are undertaken partly by the instruments division and partly by the marine division of the office.

Daily weather study—Telegraphic reporting and anemograph stations.

2. Moved specially by the loss of the *Royal Charter*, in 1860 Admiral FitzRoy in cooperation with Le Verrier and with the support of the Prince Consort, began daily telegraphic reports from stations in this country and subsequently from France. With the aid of charts prepared from the observations, he commenced the issue of "forecasts" and "storm warnings." This was the very beginning of what is now the forecast division of the Office. The procedure was sharply criticized by the scientific authorities of the time, and upon FitzRoy's untimely death in 1865 the Board of Trade took the matter up with the Royal Society. Upon the report of an interdepartmental committee (Board of Trade and Admiralty) a new departure was taken.

Observatories of the first order.

3. In 1867 a grant-in-aid of £10,000 [\$48,665] was assigned to a Meteorological Committee (unpaid) to be appointed by the Royal Society and having the following enlarged duties, viz:

(a) To continue the work in maritime meteorology of the meteorological department of the Board of Trade.

(b) To continue the study of weather by means of daily telegraphic reports, but not to issue forecasts or storm warnings. (The storm warnings were replaced [i. e., resumed] by request of the board of trade, but the forecasts remained in abeyance till 1879.)

(c) To bring to the assistance of the study of weather, the records obtained from self-recording instruments at seven special land observatories established for the purpose. (This marks the introduction of observatories into the Meteorological Office system. There are now 5 meteorological observatories, two of which include magnetism and seismology, and a central observatory for the study of the upper air.)

Climatology and the meteorology of the globe.

4. In 1872 an International Conference of Meteorologists was held at Leipzig, which was followed by international congresses of duly accredited representatives at Vienna in 1874 and ultimately at Rome in 1879. These international meetings concerned themselves partly with the exchange of information by telegraph between countries in Europe, and also with the study of climate which is primarily of local or national importance, but ultimately has to do with the meteorology of the globe.

Exchange of publications.

These meetings also led to the organization of an elaborate exchange of publications, so that a meteorological office has become the most cosmopolitan of all institutions and is in direct communication with every civilized country.

The international meetings not only increased the importance of the daily weather exchange, but introduced a new subject, climatology, into the work of the Office, which in England and Scotland had been the care of voluntary societies.

Thereupon the Scottish Society, through representatives in Parliament, demanded a subvention and failing that an inquiry into the administration. There was also much dissatisfaction about the marine work, and the inquiry was granted by the Treasury, which appointed a committee of inquiry under the chairmanship of Sir William Sterling Maxwell.

Statistical division—Special researches.

5. Upon the report of that committee in 1877 the Treasury decided to revise the constitution, to place the actual direction as well as the general control of the Office in the hands of a paid Council appointed by the Royal Society with the sanction of the Treasury. The grant became £14,500 (\$67,564). Climatological work was added to the obligations of the Office and is now represented by the statistical division, which concerns itself with the publication of the official yearbook. Also by the same instrument "special research," which included experimental work of various kinds, was recognized as a legitimate object of expenditure.

Daily information for newspapers—Evening telegraph service.

6. In 1879 the study of weather with the aid of daily telegrams and of self-recording instruments at observatories was pronounced to be sufficiently far advanced to justify the issue of forecasts, and they were accordingly

issued at 11 a. m. daily to public offices and newspapers gratis, and to "subscribers." But the Times newspaper desired also an evening issue that might be printed in the morning paper. For some time the money necessary for the additional service was provided by the Times and subsequently by a syndicate of newspapers. Then the Government accepted the obligation and increased the grant first by £500 and subsequently by £300 more on that account [\$3,893 in all]. The Office was accordingly charged with a new duty—the supply of weather information in the evening to newspapers. It is now associated with evening duty for the Admiralty and military air stations.

7. From 1880 things went on without change for more than 20 years, but in 1903 the Scottish members of Parliament again demanded an inquiry on account of the failure of the Scottish Society to obtain a subvention sufficient to maintain the observatory on Ben Nevis from the grant made to the Meteorological Office. Another inquiry was set on foot by the Treasury, and a committee appointed under the chairmanship of Herbert Maxwell. This committee reported in 1904, and resulted ultimately in the Treasury Minute of May 20, 1905, already referred to.

Réseau mondial—Library.

In the meantime the library had become a most important matter, and the compilation of information about climate and weather in the various parts of the British Empire practically constituted a new department of activity. The pressure on the one hand of the International Meteorological Committee and on the other hand of the study of solar physics, has gradually led to the recognition of an obligation toward a *réseau mondial* as specially incumbent upon the Meteorological Office as the central institution of its kind for the Empire. This has become part of the duty of the secretarial and library division of the Office.

Investigation of the upper air.

Since the Meteorological Committee was constituted, in 1905, many changes have supervened; telegrams from Iceland, wireless telegrams from ocean steamers; the air departments of the navy and the army; the absorption by the Office of the whole duty as regards climatology, previously discharged by the societies with the aid of a subvention. The Office has also become the central institution for the meteorological investigation of the upper air. It has taken over the direct control of observatories which were previously under separate authorities, and this step has brought with it the responsibility of the office for certain aspects of terrestrial magnetism as well as of atmospheric electricity and seismology. These changes have been associated with an increase of the grant to £20,000 [\$97,330].

Colonial observations.

The Office has also become an advisory center for those British colonies which have no separate meteorological organization, and it also assists the meteorological institutes of the Dominions in the selection and purchase of instruments.

British Rainfall Organization.

Thus the horizon of work of the Office, which was originally limited to the collection and discussion of observations from the sea, has now become very wide;

but it does not yet include all the British meteorological interests. The important subject of rainfall over the British Isles is still the care of a private organization—"The British Rainfall Organization." The Meteorological Office makes no attempt at the detailed representation of rainfall, and only deals with rainfall as part of climatology.

When, therefore, the application of meteorology to agriculture is considered, so far as the Meteorological Office is concerned, anything which is dependent upon the detailed study of the distribution of rainfall is not necessarily included.

In a recent communication to the Treasury the purposes which the Office keeps in view have been defined in the following terms:

I. The collection of observations from ships on all oceans, together with the discussion and publication of meteorological results for the benefit of sailors and as a contribution to the meteorology of the globe.

II. The collection and publication of reports received by telegraph and the issue of forecasts and storm warnings based upon them.

III. The maintenance of observatories and anemograph stations to furnish material for the scientific study of the phenomena of weather as exhibited on the daily charts, and the application of the study to the improvement of forecasting and other purposes.

IV. The organization and maintenance of a trustworthy public memory of the weather, which is available for reference at any time by all classes of the community. This also forms a basis for the study of the climatology of the United Kingdom in comparison with that of other countries, and in its relation to agriculture, public health, and other public purposes; to discuss the observations with a view to the definition of climatic factors for this country in comparison with others; and ultimately to establish the relationships of seasons and more general laws of climate and weather that should lead up to a rational forecast of coming seasons.

V. Cooperation with the British dominions and foreign countries for improving the organization and the instruments by which the purposes enumerated above are to be pursued, and for the effective representation of the meteorology of the globe.

Apart from the question of special researches by individuals at the central office or at the observatories, the means which are adopted by the committee for securing these objects are set out in the Circular 001, together with a copy of the latest report [1914] of the Committee, which gives on pages 6-8 the names of the staff, consisting of about 80 persons.

These facts will enable his excellency to form an opinion as to the rather complicated structure which is represented by the meteorological organization of [Great Britain]. References are given to the original documents which form the material through which the gradual development of the structure can be traced. It consists of a central office, with branch offices, observatories, and stations. The work of the central office is in five divisions, viz:

1. Marine meteorology.
2. Forecasting, storm warnings, and dynamical meteorology.
3. Climatology and statistics.
4. Instruments and equipment for observatories and stations.
5. Library, inquiries, and *Réseau mondial*.

METEOROLOGY AND AGRICULTURE.

Some addition is necessary with regard to the important and difficult question of *la météorologie agricole*. It is really an open question whether the responsibility for the application of meteorology to agriculture belongs to the Meteorological Office or to the Board of Agriculture and Fisheries in England and the corresponding departments in Scotland and Ireland. The traditional attitude of the Meteorological Office is that it collects and digests meteorological information which the agriculturist can apply

if he wishes, and from that point of view the following publications by the Meteorological Office are regarded as suitable:

FORECASTS.

1. The *Daily Weather Report* with the provisions set out for telegraphing forecasts for a small fee to those who are willing to pay for the telegrams.

Forecasts are prepared throughout the year each morning at 10 a. m. and each evening at 7 p. m., and during the harvest season—June to September—in the afternoon, specially for agriculturists.

STATISTICS.

2. The *Weekly Weather Report*, which was projected specially with a view to agriculture and public health, gives a summary of the pressure, temperature, sunshine, and wind in a form which was designed to be specially suitable for agricultural purposes. This report has now been continued for 36 years and forms a homogeneous body of statistics week by week, which is, for that purpose, probably unrivaled in the world. But it has a very small circulation outside official circles.

3. The *Monthly Weather Report* which gives the usual climatological information for about 300 stations in the British isles.

In actual practice these provisions are very little used by agriculturists. Many persons are willing to receive forecasts by telegraph, but are unwilling to pay for the telegrams; it is entirely contrary to the instinct of the British race to pay for anything until its value has been made undeniably clear, so that the farmer and the Government are both waiting for the utility of the forecasts to be demonstrated beyond cavil. Yet that can only be done by trial, and nobody has yet been found who is willing to pay the cost of an adequate trial on a large scale. The Meteorological Office could, if the committee wished, undertake that experiment, but it would mean diverting some of its funds from meteorological study to meteorological applications. It is naturally disposed to make quite sure of success before it embarks on a speculation of that kind, and certain success is the reward [only] of careful study. No institution with scientific instincts is disposed to commit itself to the position that its knowledge is complete and that it can forego any further investigation, especially in such a subject as the study of weather.

The climatological aspect of *la météorologie agricole* is a matter of the greatest difficulty. The practical farmer has made his own study of weather and used it in his own way without committing the results to writing. The Meteorological Office commits a vast number of figures to print without knowing what their precise application to agriculture is. All are agreed that agriculture depends upon weather, but to ascertain the manner in which the figures of the meteorologist can be applied to supplement the farmer's practical experience of weather is a matter requiring something that approaches to genius.

The relations between the Meteorological Office and the boards of agriculture in the United Kingdom are of the happiest, but neither side knows exactly how nor where to begin. Some progress has, however, been made in this country. Some years ago the Meteorological Office issued a note about the wheat crop in relation to the rainfall of the previous autumn, and this was taken up by a member of the staff of the Board of Agriculture, who produced a most valuable discussion by modern statistical methods of the relations of weather and crops for one district of England.

EDUCATION.

The further development of the application of meteorology to agriculture is largely dependent upon education in rural schools. The study of weather is now becoming

a part of education in many schools, rural as well as urban, so that the prospect of more effective organization is good. The provision for this is shown in Circular E .03.

But thus far as regards organization, at present the formal responsibility of the Office is limited to preparing forecasts and compiling statistics which will be indispensable when further investigation has so far developed the laws of weather as to allow of forecasting coming seasons.

That is one of the avowed objects of the *réseau mondial*, and the work thereupon must therefore also be regarded as a contribution to *la météorologie agricole*, although the practical farmer would probably not so regard it.

ANSWERS TO INQUIRIES.

Perhaps the most valuable provision of the Meteorological Office at the present stage is the provision for answering inquiries about the weather on the part of the general public. Any public department and any private person may ask any question that can be answered by a knowledge of the facts and laws of weather, and to such questions answers are given with all the intelligence that the Office can command. Many inquiries are answered, and the inquirer often finds the Office to be possessed of information of which he was unaware.

This provision allows inquiry to be directed along the lines which the agriculturist opens; among the subjects which have already been the subject of inquiry may be mentioned—spring frosts, and the protection of vegetation by "smudging"; autumn frosts; the effect of gunfire upon rainfall, particularly during harvest; spells of fine weather for harvest; temperature in relation to sugar growing; the limits of forestation prescribed by temperature; atmospheric humidity in relation to brewing.

By watching the trend of these inquiries, and by the organization of the means of preparing intelligent replies, the Meteorological Office hopes to approach the question of *la météorologie agricole* on lines suggested by agriculturists themselves, and at the same time by encouraging the development of weather study in schools to lead up to the spontaneous use of the information compiled in the Office.

If necessary, the form of the information which meteorologists have hitherto put forward as representing the main features of climatology will be altered so as to meet the needs of the agricultural inquirer.

In fine, it may be said that at present the Meteorological Office is more concerned with the means for organizing *la météorologie agricole* on a satisfactory basis than with any organization actually in operation.

WEATHER BUREAU EXHIBIT AT SAN FRANCISCO, 1915.

By J. CECIL ALTER, Observer in Charge.

[Dated: Denver, Colo., Sept. 7, 1915.]

The allotment of space for the United States Weather Bureau exhibit at the Panama-Pacific International Exposition was made early in July, 1914, and a detailed outline of the exhibits, and the proposed arrangement, prepared, which was approved by the chief of bureau, and by the representative of the Agricultural Department on the Government Exhibit Board.

About 700 visitors to the Weather Bureau exhibit were estimated from partial count the first afternoon, February 20. There being no provision for illuminating the exposition palaces, the exhibits were closed at 6 p. m., and

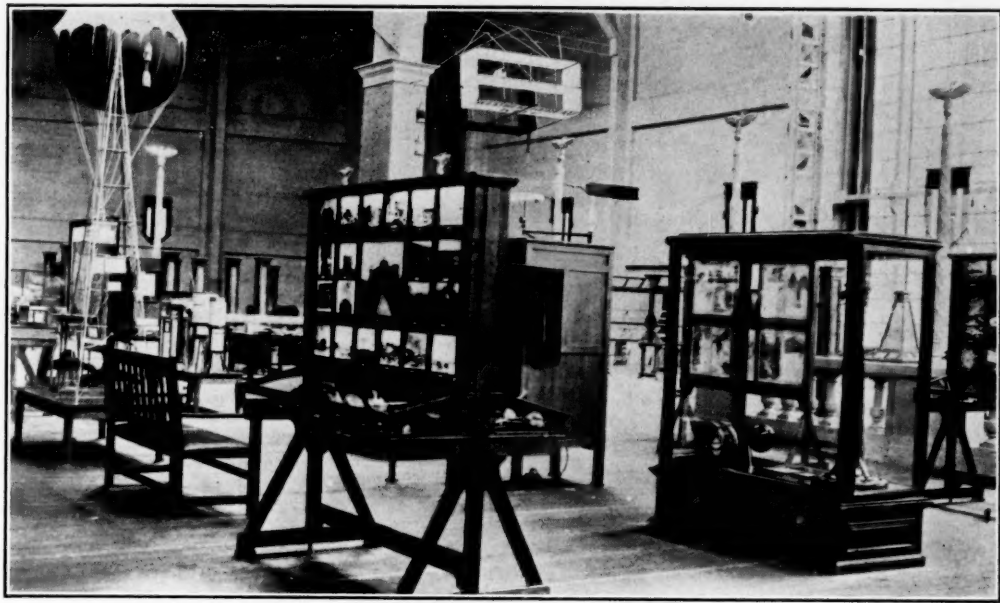


FIG. 1.

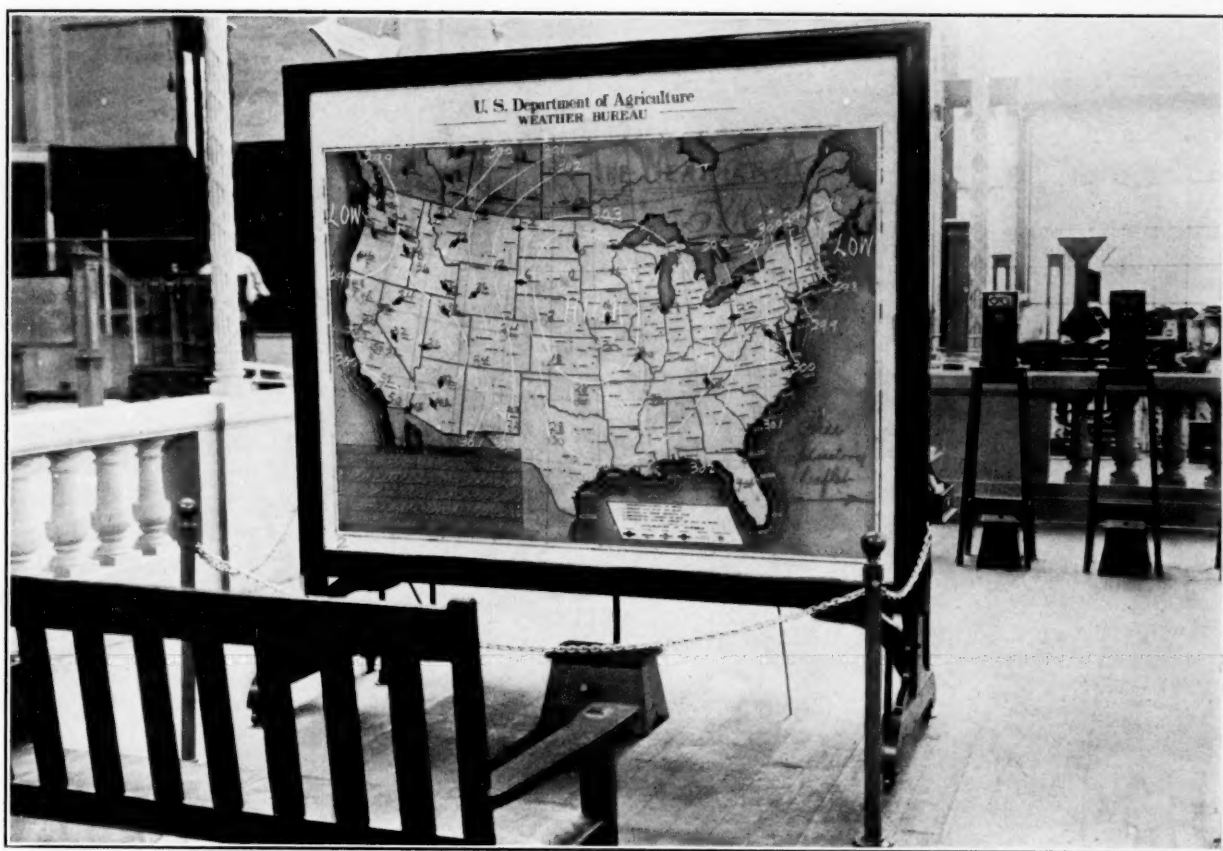


FIG. 2.

WEATHER BUREAU EXHIBIT AT PANAMA-PACIFIC EXPOSITION.

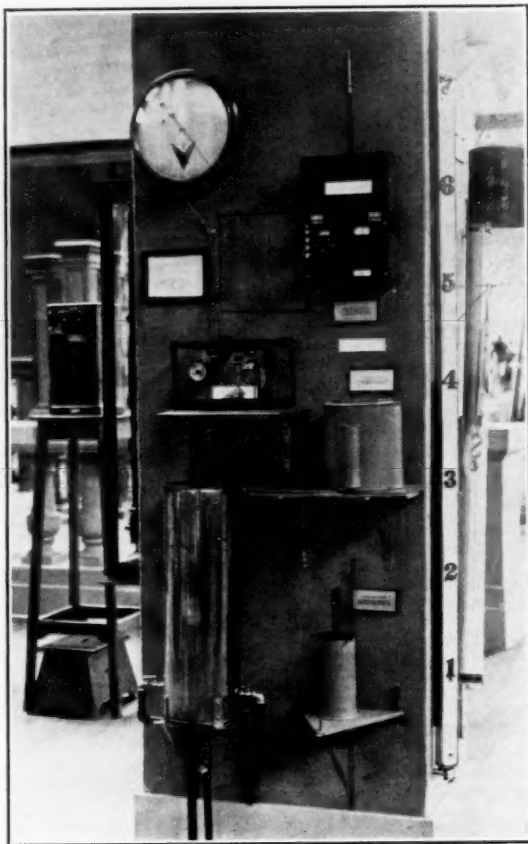


FIG. 3.



FIG. 4.

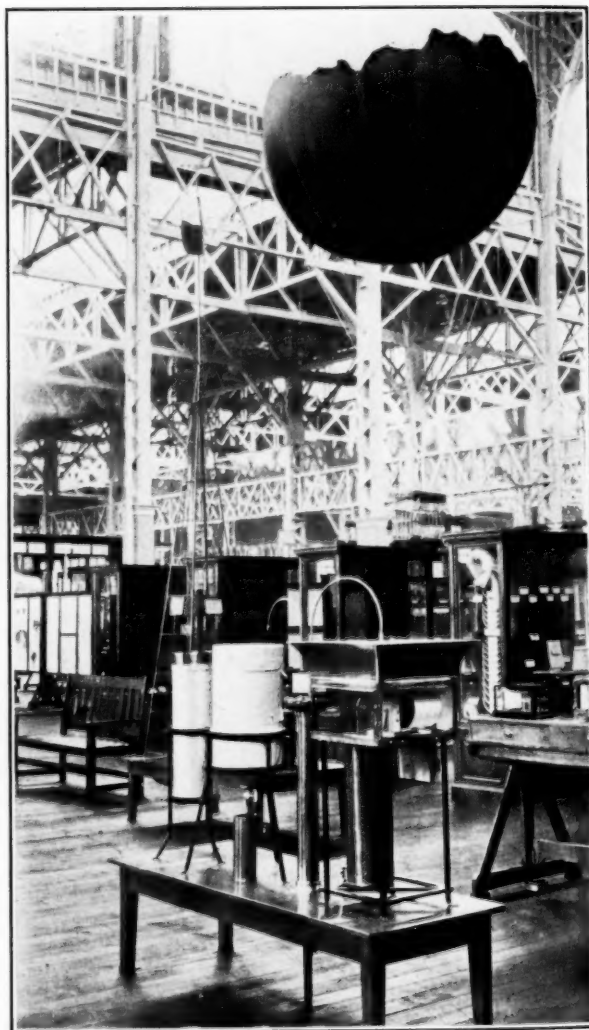


FIG. 5.

WEATHER BUREAU EXHIBIT AT PANAMA-PACIFIC EXPOSITION.

opened each morning at 9 o'clock, except Sundays, until in April, when the Government Exhibit Board managing all exhibits made by the Government, left the roped entrances to the Government exhibits open on Sunday.

In February the approximate total attendance in the Weather Bureau exhibit, estimated from occasional actual count, was 1,800; March, 4,700; April, 6,100; May, 9,300; June, 10,500; July, 11,000; and August, 11,000, many being high school and college classes, all of whom spent more or less time examining the exhibits and listening to demonstrations.

The exhibit occupies a space 28×59 feet (1,652 square feet) in size, located near the south or main entrance to the Palace of Agriculture, being a corner of the area occupied by the Department of Agriculture. The main avenue through the palace, 16 feet wide, bounds the space on the west, an aisle 12 feet wide and the Government-space balustrade form the south and the east boundaries, and a 7-foot passageway at the north separates the Weather Bureau space from other bureau exhibits. The agricultural exhibits of the Argentine are across the south and east aisles.

The exhibit is open in arrangement, a view being afforded of practically the entire space from every side and corner. The floor space actually occupied by the stands, tables, instruments, and the massive balustrade is only 17 per cent of the total exhibit space allotted to the bureau.

The cases, tables, and other furniture are finished in light oak, giving a uniform and pleasing appearance on the oiled pine floor. The glass weather map, the wind-instrument tower carrying its active instruments, the model storm-warning tower, the kite and the balloon suspended above the general exhibits are visible from all adjacent exhibits.

The new 8-foot glass map of the United States, upon which the prevailing weather conditions throughout the country are placed each morning, fronts the north aisle at the east end of the space and a large settee in front of the map upholstered in leather, is usually well patronized. A low chain on posts serves as a railing in front of the map. The weather reports are received by telephone through the courtesy of the officials at the San Francisco office of the bureau, the map being completed about 11 a. m. daily. (See fig. 2.)

A small literature rack at the end of the map frame carries for free distribution the booklet, *The Weather Bureau*, the leaflet, *Explanation of the Weather Map*, and the card, *Explanation of Weather Flags*. The daily map printed at the local office of the bureau is also posted regularly near by, together with the *National Weekly Weather and Crop Bulletin*.

The principal instrument stand, located near the map, was specially made to suit the needs of the exhibit and to conform with the architecture and finish of all other Government furniture on display. There are three drawers on a side and space for the dry-cell batteries underneath. The size is 3×6 feet, the same as the station instrument stand. On it is shown the triple register in operation, being connected with the wind vane anemometer, rain-gage, and sunshine recorder, as usual on all regular stations, the two latter records being alternated for demonstration. Cards and labels on the case and on each pen explain the records briefly.

The thermometric sunshine recorder is rigidly mounted in the center of the table, a specially mounted electric lamp being placed adjacent to operate the recorder arti-

cially as desired. A 16-candlepower lamp suffices. At the other end of the table is a single-register instrument recording wind velocity simultaneously with the wind-velocity pen on the triple register. On this stand also are the telethermograph (alcohol bulb pattern), the aneroid barograph, and the hair hygograph, all in operation at correct values. Previous records are left near each instrument.

The rain-gage display stand, near the instrument stand, is 2×6 feet in size and 18 inches high. It carries the 8-inch gage complete, the tipping-bucket and the new Marvin weekly float gages; the last two are operated almost continually by running water from the city mains. Drainage is provided so that no attention is necessary, except to drain the contents of the float-gage reservoir occasionally while this gage is being operated. A record sheet containing rainfall records made on this new gage is exhibited in position on the gage by means of the special glass panels of the gage cover. (Fig. 5.)

The regular mercurial barometer case as supplied to stations is mounted on a building post in the midst of the exhibit space; a station mercurial barometer is shown, and by its side hangs another of similar pattern with the cistern partly cut away to show the mechanism.

The Marvin automatic river-stage indicator is exhibited on the side of this post; the stillwell, operating mechanism, and dial are connected on short circuit from batteries placed inside the framing of the post. The stillwell is provided with a water-supply pipe and a drainage cock, for ready demonstration of the instrument. A special glass cover is provided for the mechanism, so that its operation may be observed. The stillwell is near the floor, the mechanism about eye high, and the indicator dial about 7 feet from the floor. (Fig. 3.)

The new style telethermoscope is mounted on the same post surface with the river gage, its batteries (dry cells) being with others within the post. The bright bulb is placed just above the case, which is mounted on edge for better examination and operation.

The compensated siphon barograph, Marvin system, placed on a side of the building post, is recording continuously at current values.

The Marvin float-evaporimeter, in its stillwell with water, is placed under the telethermoscope on brackets. The new evaporation tank, on proper wood base, containing the requisite depth of water continually, with improved hook-gage installed, is located nearby on the floor, at proper elevation.

On another edge of the large post (fig. 4) is the snow measurement apparatus. The Marvin density tube and spring balance are mounted on a bracket. The copper pail and spring balance are on a bracket above the tube, and the Kadel snow stake is mounted cornerwise against the post to show its graduations; the 3-foot hickory measuring stick is made fast nearby.

An electric fan on a bracket above the snow measurement apparatus operates the anemometer about 7 feet away. Above the electric fan, and about 15 feet from the floor, is a large bracket carrying the 10-inch model storm-warning lanterns (oil burners). The lantern halyards are rove on a pulley and the lanterns may be lowered for examination.

The combined anemometer wind-vane support, is anchored to the floor without braces or guys by means of bolts through the 3-inch floor. The anemometer runs at a velocity indicated at about 6 miles per hour continuously. The cups are about 11 feet from the floor, and

the 4-foot vane is 6 inches higher. The wind-direction contact box, about 3 feet from the floor, is left open for examination. The battery wires pass from the hollow support pipe under the floor to the triple register 15 feet away.

Nearby is a table carrying a model farm residence properly wired for lightning protection according to plans and specifications by A. J. Henry. Five dry cells and a spark coil such as is used in amateur wireless telegraphy, connected with the house wiring system and with a wire having a loose end, permit an attractive demonstration with this exhibit; when the loose end of the wire is brought near the tips of the lightning rods or any part of the house wiring system, a stream of crackling sparks will jump an air gap of about $1\frac{1}{2}$ inches, and by a slight manipulation several streams of sparks may be produced, resembling lightning in appearance.

The major parts of the Marvin pyrheliometer, equatorial mounting, also stand on this table; the reading telescope, scale, galvanometer, and other delicate parts are in a closed show case nearby. A photographic sunshine recorder, shown with exhibit base, is also on this table.

A low stand, 18 inches high and 3×6 feet in size, carries the model storm-warning tower, with its lanterns and the weather flags, the appropriate weather flags (small size) being displayed for to-morrow's weather forecast. The flags are about 17 feet from the floor. Small 6-inch models of electric storm-warning lanterns are about 12 feet from the floor and may be lowered for examination. A small brass model of the new Marvin shielded rain-and-snow-gage, one-fifth actual size, is mounted on the same stand.

A screen for displaying photographic prints is near the wind instrument tower. It has two surfaces about 6 by 6 feet in size for large illustrations and 12 views are shown. Nearby is an autoprojectoscope for automatically projecting lantern slides continually; a large leather upholstered settee in front of this picture machine invites visitors to rest a while. The views shown are about 2 feet square, each view being exposed about 15 seconds, though with a push-button cord any slide may be held as long as desired. Appropriate explanatory slides accompany each view or series of views, there being at least six views of every branch and special feature of the Bureau and its work.

At the southwest corner of the space is an exhibit transparency stand having two show cases beneath the transparency frame. (See fig. 1.) One case contains textbooks and Weather Bureau publications, with climatological statistics or averages for practically all parts of the world. The adjacent show case contains the Marvin nephoscope, complete; a kiosk aneroid barometer, and the same showing works only; a pocket aneroid barometer; the kite meteorograph, and the balloon meteorograph with extra aluminum sheets for records. All show cases are plush-lined, and have glass panels on sides and top.

A similar display stand with show cases is at the northwest corner of the space; one case carries the pyrheliometer parts, a short range thermograph (metal coil pattern), two ordinary thermometers, a maximum and a minimum thermometer on a Townsend support, a hand sling psychrometer, and a regular station whirling psychrometer, with shortened handle, and no support. The other case contains a Lambrecht's hygrometer, Marvin's kiosk hair hygrometer, a burette tube, an electric sunshine recorder, Lind's old style anemometer, a small zero-setting anemometer for light air movement, elec-

trical contacts for wind direction registration, a Marvin kite anemometer complete, and a regular station anemometer with cups, these instruments having been taken apart when necessary to show them in the case.

Between the transparency stands, on the main aisle, is the Bosch-Omori seismograph in an exhibit case. The seismograph pen vibrates continually with the minute movements of the floor, though the record is not traced. Enlarged copies of records of the San Francisco earthquake in 1906, and others, are shown in the case. The pens, drum, and time-marking devices shown are by Marvin.

The Marvin box kite is suspended by a wire about 15 feet overhead and carries an empty aluminum meteorograph case. A sounding balloon is also suspended similarly, the empty meteorograph basket, attached properly to the overslung parachute, being just above visitors' heads. The balloon is inflated with compressed air. (Fig. 1.)

A display fixture containing 24 wing frames, providing for 96 surfaces, 22×26 inches in size, for photographs, charts, and maps, is placed against the back of the glass weather map. On this fixture, and on the picture screen, transparency stands, and lantern slide projector already mentioned, are shown several selected views each, of Weather Bureau buildings, mountain snow scenes, wireless stations, kites and balloons in use, cooperative stations, instrumental exposures at stations, many special single instruments where the instrument is not exhibited, river and flood views with river gages, the Wagon Wheel Gap (Colo.) experimental work, also the similar work at Ephraim, Utah, the frost work in the fruit regions, and in the cranberry marshes, copies of automatic records of special or historic storms, cloud and fog forms and types, snow and ice crystals, forecast verification map, West Indies storm tracks and Panama Canal sailing routes, long record precipitation charts, maps of all regular and special stations of the bureau, the corn, wheat, cotton, and other special services; consecutive series of Washington weather maps; series of the Northern Hemisphere maps; foreign weather maps; special diagrams of precipitation distribution by months at selected stations; the snow survey work in Utah; special storm views, showing tornado damage, waterspouts, hail, and damage thereby, lightning photographs and lightning effects, deep snow views, ice gorges in streams, vessel warning stations, vessel reporting service, coast storms and effects and other miscellaneous views.

Two stereoscopes each contain 48 views of the work in the central office of the bureau, the work at a typical climatological station (Salt Lake City), the snow measurement work with the Marvin tube and shielded gages, the cooperative experimental station at Ephraim, Utah, some river views, and a number of cooperative stations. (Fig. 2.)

CLIMATOLOGICAL STATIONS AND LOCAL AUTHORITIES.

We print below remarks by the director of the British Meteorological Office addressed to the local pride and local interests of Great Britain and Ireland. Probably the conditions of the time rather than the natural course of evolution of meteorological work, have influenced him in this case. The best interests of meteorology and of climatology require that so far as possible the equipment, installation, inspection, and observing methods be under a single centralized control. Only under such conditions can science be assured of that degree of reliability, uniformity, and homogeneity which is the prime essential

in all meteorological work. World meteorology has always suffered from lack of homogeneity due to national lines of division; that gigantic undertaking of the 70's and 80's the "International simultaneous observations" under the direction of Gen. A. J. Myer, was not altogether perfect in this regard. Even within the limits of a nation observations will not be uniform and comparable unless under a centralized control. It is not often that the United States passes through a phase of national development earlier than does Great Britain; but in this case we actually seem to have done so. Our country has had its experience with State and other local weather organizations with the result that local pride or local interests did not prove strong enough to maintain the work in adequate form, with one or two noteworthy exceptions.

Strange to say, it may be safely opined that Dr. Shaw's appeal would not find any response in the American public consciousness. Here we seem to lean more and more strongly toward governmental financing of all undertakings, no matter how pronounced their local value and bearing. Of course, in certain lines, such as metropolitan rainfall réseaux, local corporations have shown initiative and energy of their own; but they seem to have been forced into such work by Dame Nature rather than to have undertaken it from any sense of pride in securing a knowledge of their locality.—C. A., jr.

MEMORANDUM BY THE DIRECTOR OF THE METEOROLOGICAL OFFICE.¹

[Signed: W. N. SHAW, London, Apr. 27, 1915.]

In the present emergency in national affairs the Meteorological Committee desires to call attention to the position of the Meteorological Office in relation to the collection of observations from what are technically known as "climatological stations;" that is to say, from stations which are maintained, not by the office in connection with the public daily service of forecasts and gale warnings, but by local authorities or private persons. They contribute observations to be used by meteorologists for the study of the details of climate and weather in the British Isles, and by the public who require information about the weather for various purposes.

The Meteorological Office is a central depository of transcripts of meteorological observations of various kinds in every part of the British Isles, of the British Empire, and indeed of the whole world, not because the information is essentially necessary for or immediately applicable to the work of forecasting and the study of daily weather which, so far as observations on land are concerned, are its primary duties, but because an organized central storehouse or memory of the experiences of weather for a long series of years is of great public utility and more effective than any compilation which otherwise individuals would be able to make for their own use. By agreement between the office and the Scottish Meteorological Society the Meteorological Office, Edinburgh, discharges a similar duty with special reference to Scotland.

In the course of the past 20 years a large amount of valuable information has been compiled, the existence of which is hardly realized. It is still far from complete, but I may be permitted to illustrate the usefulness, or at least the appositeness, of an efficient public memory by recalling a report which I happened to see some years

ago in the Westminster Gazette, of a lawsuit in which a tobacconist sued his neighbor for damage to a case of cigarettes, alleged to be due to rain coming through a broken skylight. It was acknowledged that the skylight was broken by the neighbor's son and, according to the report, "all went well until a mild-mannered gentleman from the Meteorological Office" proved that it had not rained since the skylight was broken, and the plaintiff's case had to be abandoned.

In order to be effective the collection of information should be carefully organized. The preservation of a trustworthy and sufficient memory of past weather is primarily a matter of urgent local importance. The weather is an element in the profit and loss account of every individual, of every parish, of every district, whether urban or rural, of every county, and of every State; and the preservation of an efficient record of these events is just as important for the persons or authorities concerned as the record of the money transactions in which they are engaged. The difference between the two sets of experiences is that one is beyond the control of the individual or local authority and the other is not; but no steward of his own or other people's interests would be regarded as wise if he left out of account the gains and losses which he could not control.

The question of meteorological observations, or weather records, may be put in this general form: Here is a spell of rain which the house gutters, the local drains, the roads, gulleys, and streams have to carry away; a snow-storm which may make the neighborhood impassable; a hailstorm which damages the crops; a drought, or a long frost, which endangers the water supply; a wind which brings down all the loose tiles and chimneys. Are these events to be regarded as normal and to be provided against by suitable precautions, or are they outstanding risks which should be left to chance?

Only by an adequate public memory can an answer be given, and hitherto the provision of the material for an answer has been left mostly to private enterprise. The claims of science have usually been urged as an encouragement to private enterprise, and without doubt such observations are indispensable for the scientific study of weather; but they are equally indispensable for the proper conduct of the ordinary affairs of life. Since the study of weather began to be organized on a scientific basis, circumstances have changed. The life of the individual and of the community is not nearly so self-contained now as it used to be; it is much more dependent upon facilities for communication with the rest of the world. The increase of those facilities enables the experience of many to be used for the advantage of each in a far greater degree than was possible in the olden days.

To take an example, the practice of insurance is far more widely spread than it used to be. Taking the case of insurance against hail, the premium should be different according to the locality; but so far as is known the localities in their corporate capacity keep no records, and in consequence the premium is fixed for them upon information privately compiled by the insurance companies; that is to say, by one of the parties to the bargain. Many other forms of insurance against weather are possible, but only when the risk can be properly computed by means of ascertained facts. This Office has recently been concerned in a legal dispute as to whether damage to property during a squall of wind accompanied by incessant lightning was directly due to the wind or to the lightning. A fine distinction, upon which the validity of the insurance turned, and which suggests some revision

¹ Reprinted from Tenth Annual Report of the Meteorological Committee . . . for the year ended March 31, 1915 (the 60th year of the Meteorological Office). London, 1915. pp. 75-78.

of the practice of insurance in the light of recorded experience of weather.

Local authorities have given little consideration to these matters, and individual farmers and others have trusted to their own reminiscences. It is, in fact, apparent that the balance of prosperity has been so large that it has not hitherto been felt necessary to pay much attention to the profits to be made out of the weather, or to economize the losses which it causes, but when the pinch of adversity comes, as it must come after the squandering of so much of the world's wealth in the war, the reduction of any risk by the use of organized knowledge is at least worthy of consideration. The stress of war is therefore a reason for organizing the study of weather, not a reason for postponing organization to a more prosperous season.

No one will deny that a careful record of the weather regularly compiled from day to day on a definite plan is, in the long run, a better basis of action than the longest stretch of personal reminiscences, just as a daily record of river level is better than an occasional mark on the parapet of a bridge. With the change of circumstances, from the comparative independence of the homestead to mutual dependence of town and country, and from the abundant prosperity of past years to the adversity that lies in front of us in the near future, the preservation of an adequate record of the events of weather for comparison with past times and with other localities has also changed from being a matter of scientific and personal curiosity to a necessity for the community. It is from that point of view that it should be regarded; the additional advantage that may accrue from scientific meteorological study is all to the good, but it is another matter.

The unanimity with which the health resorts have made provision for careful records of weather shows that a knowledge of the weather must be looked upon as a valuable asset, and it is equally so for any other locality. A contractor who undertakes work for a local authority must either know something about the weather or allow a wider margin for contingencies than is really necessary; the locality must either supply the information or provide the margin.

Hitherto the observations upon which we depend for supplying information about the weather in all parts of the British Isles have been largely those of country clergy and landowners; but the drain upon their resources, particularly in men, has begun to diminish the number of observations available. Already in Ireland the observations are altogether inadequate, and when, for example, questions are put as to the parts of the country where climatic conditions are favorable for afforestation, we can not give a satisfactory answer, because the localities have no record of their experience. Moreover, the distribution of observing stations depends not upon the present and future requirements of the public but upon the existence of a local volunteer.

It is submitted, therefore, that the local authorities should give serious consideration to the question of an adequate record of weather. The Meteorological Office has been active in collecting and organizing the meteorological information that was known to be available. This has given the impression that the office, as the creation of the central Government, ought itself to provide any observations that may be found necessary for any purpose whatever; but such an impression is quite erroneous. Out of 500 observatories and stations which contribute observations to the office for the

benefit of the public, only 36 are maintained or subsidized out of office funds. A considerable number are maintained by local or statutory authorities and the remainder by private persons at their own expense. It is natural, and perhaps laudable, that in the matter of weather the city of Westminster should rely upon the Meteorological Office, instead of itself, for its memory; and it is not unreasonable that the office of works, in a dispute over a contract, should apply to the Office (unsuccessfully, I fear) for details of weather between Avonmouth and Bristol, and their relation to the average. But it would be absurd, for example, for the Council of the County of Warwick to rely upon London to know what weather had been experienced in Warwickshire; or for residents at Hindhead to live in ignorance of their own climatic conditions until the Government provides the information. The natural order is just the reverse; the Meteorological Office should naturally appeal to the localities to know what has transpired [happened] there, and it is a matter for surprise how many of the county councils, when appealed to, would be unable to say what the weather had been in their county since it was under their charge. The whole situation arises from the mistaken notion that to satisfy the condition of utility at all, knowledge must be useful here and now, and that nothing need be preserved for which the officials of to-day have no obvious and immediate use. It is the memory which goes back longest that is the most effective, and therefore most useful.

It ought, in fact, to be the function of the Meteorological Office to reduce, rather than to multiply, meteorological observations, by proper organization and by the suggestion of coordination, where coordination is economical. The following guiding principles seem to be applicable: For keeping its water supply and drainage properly under observation, every parish ought to have its rain-gage and the parish council might see to that. A district council might keep a regular record of temperature and weather as well, for its own district; while in every county there should be, for official purposes, a proper number, and no more, of fully equipped climatological stations which should be centers of information about the weather and its ways for all concerned.

THE TROPICAL HURRICANE OF SEPTEMBER 29, 1915, IN LOUISIANA.

By ISAAC M. CLINE, District Forecaster.

[Dated: Weather Bureau, New Orleans, La., Oct. 21, 1915.]

The most intense hurricane of which we have record in history of the Mexican Gulf coast, and probably in the United States, moved northward over southeastern Louisiana and southwestern Mississippi during September 29, 1915. The territory traversed by this hurricane, especially near its center, is well covered by cooperative observing stations, and the records of meteorological conditions from these stations furnish unusually interesting material for study in connection with hurricanes. We have very complete barometer readings from New Orleans, Burrwood, and Morgan City, La., and Bay St. Louis, Miss., and observations of weather conditions and changes in wind direction on and near the path of the center of the hurricane from the time it struck the Louisiana coast until it passed out of the State, a distance of about 150 miles.

We shall first consider the meteorological conditions and special features attending the hurricane, and then take up the issue and distribution of warnings by the Weather Bureau, the action taken to protect lives and property, and the value of the warnings.

GENERAL METEOROLOGICAL CONDITIONS.

Tuesday, September 28, 1915.—Early in the morning a few cirrus clouds were seen at New Orleans spreading over the sky, coming up from the south; by 10 a. m. (90th mer. S. T.) the entire sky was covered with a cirrus veil, below which were about 4/10 strato-cumulus moving rapidly from the northeast. At 11 a. m., there was 4/10 cirro-stratus moving from the northeast and 2/10 cumulus coming from the east, the higher clouds were obscured. By noon the cirrus had largely disappeared or were not visible, the strato-cumulus had decreased to about 2/10, and the sky was covered by cirro-stratus moving from the south. At 1 p. m., there was 1/10 cirrus and 3/10 cirro-stratus, all from the southwest, and 3/10 cumulus from the east. At 2 p. m., about 3/10 of the sky were covered by cirrus streamers coming up from the south and spreading to the north of the zenith; a few cirro-cumulus were moving from the south, and there was 3/10 strato-cumulus moving from the east. At 3 p. m., there was 4/10 cirrus and 3/10 cirro-stratus, all from the southwest, and there was 1/10 cumulus from the east. By SUNSET the cirrus veil had increased in thickness, merging into thin cirro-stratus and covering the entire sky, which at sunset was a faint brick-dust color, with a heavy bank of cumulus in the east. From sunset to 10 p. m., the sky was covered by a veil of high clouds as shown by observations of the stars, very few of the latter could be seen and those were of a peculiar copper tint. From 10 p. m. to MIDNIGHT the thickness of the clouds gradually increased.

Wednesday, September 29, 1915.—By 3 a. m. of the 29th the cloud cover had increased in thickness and was mainly strato-cumulus moving rapidly from the northeast; occasional heavy rain squalls occurred. By day-break the clouds had increased in thickness, about 7/10 were typical nimbus and 3/10 strato-cumulus and scud moving rapidly from the northeast. This formation of clouds continued all day and into the night, with heavy rain most of the time and excessive [see p. 493, Table II] during the larger portion of the day. After the passage of the storm center the rainfall gradually decreased in intensity and the clouds decreased somewhat in thickness until at MIDNIGHT the rain ceased; but the sky was still covered with strato-cumulus clouds moving rapidly from the west.

Thursday, September 30, 1915.—From midnight until 7 a. m. the clouds gradually decreased in density and the strato-cumulus gave way to alto-cumulus and cirro-stratus covering the entire sky. At 9 a. m. the sky was entirely clear of clouds.

PRESSURE.

From September 22 to 25, the fluctuations of the barometer show nothing more than the ordinary normal diurnal changes. The faint rise in the barometer which is supposed to precede the gradual fall indicating the approach of a hurricane did not occur. A gradual fall in the barometer commenced on the morning of the 25th and the fall amounted to about 0.10 inch in 24 hours until noon of September 28 when the fall became more rapid.

From 7 p. m. of the 28th to 7 a. m. of the 29th the barometer fell 0.18 inch.

During the 29th the barometer fell rapidly from 29.54 inches at 7 a. m. to 28.11 inches at 5:50 p. m., a fall of 1.43 inches in 10 hours and 50 minutes or slightly more than 0.13 inch per hour. From 3:10 p. m. to 5:50 p. m. the barometer fell 0.90 inch, or at the rate of more than 0.33 inch per hour. A trace of the barograph corrected and reduced to sea-level from observed readings of the mercurial barometer is reproduced in figure 5 on chart XLIII-114. Table 1 gives the readings of the mercurial barometer (reduced to sea-level) taken at 15-minute and 5-minute intervals. The readings were taken by Mr. Coberly and Mr. Harder, except that the 5-minute readings were all taken by Mr. Coberly and the instantaneous fluctuations as indicated by the movements of the barograph pen were noted by Mr. Harder, and I took the readings from 10:30 p. m., of the 29th until 12:30 a. m., of the 30th, and Mr. Coberly continued them until 7 a. m., of the 30th. The wind velocity and direction were taken from the triple-register and are given at the time of each barometer reading.

TABLE 1.—Reduced pressure, barometer fluctuations, and wind velocity and direction at New Orleans, La., Sept. 29, 1915, 10 a. m. to Sept. 30, 6:55 a. m.

Time. (90th M. S. T.)	Pressure.	Wind.		Fluctuations in pressure.	Observers.
		Velocity.	Direction.		
1915. Sept. 29.	Inches.	Mt./hr.		Inches.	
A. M.					
10:00.....	29.40	37	ne.	0.02	Coberly & Harder.
10:30.....	29.33	48	ne.		Do.
11:00.....	29.30	38	ne.		Do.
11:15.....	29.25	43	ne.	Slight.	Do.
11:30.....	29.24	53	ne.	0.01	Do.
11:45.....	29.19	34	ne.		Do.
12:00, noon.....	29.18	46	ne.	0.05	Do.
P. M.					
12:15.....	29.15	48	ne.	0.03	Do.
12:30.....	29.14	49	ne.	0.01	Do.
12:45.....	29.13	46	ne.	0.01	Do.
1:00.....	29.10	54	e.	0.02	Do.
1:15.....	29.09	50	e.	0.01	Do.
1:30.....	29.08	49	e.	0.01	Do.
1:45.....	29.06	44	e.	Steady.	Do.
2:00.....	29.05	44	ne.	0.01	Do.
2:15.....	29.01	50	e.	0.02	Do.
2:30.....	28.98	50	e.	0.02	Do.
2:45.....	28.94	54	e.	0.03	Do.
3:00.....	28.93	53	e.	0.02	Do.
3:15.....	28.90	52	e.	0.01	Do.
3:30.....	28.87	54	e.	Steady.	Do.
3:45.....	28.81	48	e.	Steady.	Do.
4:00.....	28.76	52	e.	0.02	Do.
4:15.....	28.68	63	se.	0.03	Do.
4:30.....	28.56	60	se.	Steady.	Do.
4:45.....	28.53	66	se.	0.03	Do.
4:55.....	28.44	72	e.	0.02	Coberly.
5:00.....	28.39	72	e.	0.03	Do.
5:05.....	28.37	76	se.	0.03	Do.
5:10.....	28.34	86	se.	0.02	Do.
5:15.....	28.28	75	se.	0.02	Do.
5:20.....	28.23	70	se.	0.03	Do.
5:25.....	28.17	70	se.	0.02	Do.
5:30.....	28.16	52	se.	0.02	Do.
5:35.....	28.15	44	se.	Steady.	Do.
5:40.....	28.13	42	se.	0.02	Do.
5:50.....	28.11	46	se.	0.03	Do.
5:55.....	28.13	44	se.	0.05	Do.
6:00.....	28.14	50	s.	Steady.	Do.
6:05.....	28.15	50	se.	Steady.	Do.
6:10.....	28.14	60	se.	0.05	Do.
6:15.....	28.15	44	se.	Steady.	Do.
6:20.....	28.17	46	se.	Steady.	Do.
6:25.....	28.17	48	s.	Steady.	Do.
6:30.....	28.17	42	se.	0.02	Do.
6:35.....	28.19	33	s.	0.02	Do.
6:40.....	28.19	34	s.	0.02	Do.
6:45.....	28.23	31	sw.	Steady.	Do.
6:50.....	28.26	32	sw.	Steady.	Do.
6:55.....	28.28	36	sw.	Steady.	Do.
7:00.....	28.31	31	sw.	Steady.	Do.
7:05.....	28.33	33	Variable.	Steady.	Do.
7:10.....	28.35	39	sw.	Steady.	Do.
7:15.....	28.39	39	sw.	Steady.	Do.
7:20.....	28.41	38	s.	Steady.	Do.
7:25.....	28.44	38	sw.	Steady.	Do.
7:40.....	28.54	29	sw.		Do.

TABLE 1.—Reduced pressure, barometer fluctuations, and wind velocity and direction at New Orleans, La., Sept. 29, 1915, 10 a. m. to Sept. 30, 6:55 a. m.—Continued.

Time. (90th M. S. T.)	Pressure.	Wind.		Fluctuations in pressure.	Observers.
		Velocity.	Direction.		
1915.					
Sept. 29.					
P. M.	Inches.	Mi./hr.		Inches.	
7:55	28.63	29	SW.		Coberly.
8:10	28.70	26	SW.		Do.
8:25	28.77	26	SW.		Do.
8:40	28.82	26	SW.		Do.
8:55	28.86	25	SW.		Do.
9:10	28.91	24	SW.		Do.
9:25	28.95	24	SW.		Do.
9:40	28.97	22	SW.		Do.
9:55	29.01	23	SW.		Do.
10:10	29.04	21	SW.		Do.
10:25	29.06	25	SW.		I. M. Cline.
10:40	29.09	28	SW.		Do.
10:55	29.13	29	SW.		Do.
11:10	29.14	28	SW.		Do.
11:25	29.15	30	SW.		Do.
11:40	29.16	28	SW.		Do.
11:55	29.17	35	SW.		Do.
Sept. 30.					
A. M.					
12:10	29.20	36	SW.		Do.
12:25	29.22	29	SW.		Do.
12:40	29.22	27	SW.		Coberly.
12:55	29.25	27	SW.		Do.
1:10	29.27	29	SW.		Do.
1:25	29.28	29	SW.		Do.
1:40	29.30	30	SW.		Do.
1:55	29.32	26	SW.		Do.
2:10	29.33	27	SW.		Do.
2:25	29.35	30	SW.		Do.
2:40	29.37	24	SW.		Do.
2:55	29.38	31	SW.		Do.
3:10	29.40	26	SW.		Do.
3:25	29.41	23	SW.		Do.
3:40	29.42	25	SW.		Do.
3:55	29.43	23	SW.		Do.
4:10	29.45	25	SW.		Do.
4:25	29.46	23	SW.		Do.
4:40	29.49	21	SW.		Do.
4:55	29.49	23	SW.		Do.
5:10	29.51	20	SW.		Do.
5:25	29.52	19	SW.		Do.
5:40	29.53	17	SW.		Do.
5:55	29.54	16	SW.		Do.
6:10	29.55	17	SW.		Do.
6:25	29.57	18	SW.		Do.
6:40	29.57	16	SW.		Do.
6:55	29.58	16	SW.		Do.

Barometer and wind observations taken aboard the Honduran steamship *Ceiba* were furnished by Capt. Ernest E. B. Drake, and are given in Table 2, the barometer used being the ship's aneroid, Weather Bureau No. 6224.

TABLE 2.—Observations on the *Ceiba*, 3 miles NE. of the Weather Bureau, New Orleans.

Time.	Pressure.			Wind direction and force.
	Observed.	Correction.	Corrected.	
<i>Sept. 29.</i>				
<i>A. M.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	
4:00.....	29.71	-0.11	29.60	Fresh to strong east, with frequent heavy squalls and continuous rain.
6:00.....	29.64	-0.11	29.53	
8:00.....	29.64	-0.11	29.53	
10:00.....	29.52	-0.11	29.41	
12:00 noon...	29.31	-0.11	29.20	
<i>P. M.</i>				
2:00.....	29.07	-0.11	28.96	ene. 7.
3:00.....	28.95	-0.11	28.84	e. by n. 7 to 8.
4:00.....	28.87	-0.11	28.76	e. 8.
5:00.....	28.41	-0.11	28.30	e. by s. 9 to 10.
6:00.....	28.15	-0.11	28.04	ese. 11.
6:40.....	28.125	-0.11	28.01	se. by e. 11.
7:00.....	28.22	-0.11	28.11	se. 11 to 10.
8:00.....	28.55	-0.11	28.44	sse. 10.
10:00.....	28.92	-0.11	28.81	s., moderating rapidly and rain clearing.
12:00.....	29.13	-0.11	29.02	ssw.

The above observations were taken at the ship's mooring about 3 miles northeast of the local office, Weather Bureau, and the distance from the center of the hurricane is about the same as that of the local office, Weather Bureau. It is noted that this barometer fell a little more rapidly than the Weather Bureau barometer.

Barometer readings at Burrwood, La., on the east bank at the mouth of the southwest pass of the Mississippi River, have been furnished by Mr. George E. Henderson, special meteorological observer, Weather Bureau, as follows:

TABLE 3.—Barometer readings at Burrwood, La., and on the dredge New Orleans.

Time (90th M. S. T.)	U. S. dredge New Orleans, aneroid.	Burrwood, La., mercurial barometer.	Time.	U. S. dredge New Orleans, aneroid.	Burrwood, La., mercurial barometer.
Sept. 29.			Sept. 29.		
A. M.	Inches.	Inches.	A. M.	Inches.	Inches.
2:00	29.66		9:45	29.00	
3:00		29.42	10:00	29.04	
3:30		29.38	12:00 noon	29.05	
4:00	29.56	29.38			
4:30		29.33	P. M.		
5:00		29.30	2:00	29.09	
5:30		29.27	4:00	29.17	
6:00	29.27	29.23	6:00	29.23	
6:30		29.21	7:00	29.31	
7:00		29.18	8:00	29.37	
7:30		29.13	9:20	29.52	
8:00	29.18	29.09	10:00	29.54	
8:30		29.00	12:00 midnight	29.58	

Mr. Henderson and his family, with others in Burrwood, went aboard the U. S. dredge *Benyaurd*, deeming that safer than to remain ashore. This explains why the readings of the mercurial barometer were discontinued after 8:30 a. m. of the 29th.

It is observed that the aneroid barometer on the U. S. dredge *New Orleans* (see Table 3) read 0.24 inch too high at 2 a. m. of the 29th, that it fell more rapidly than the mercurial barometer until 6 a. m., when it was only 0.06 of an inch above the mercurial, but that at 8 a. m. the aneroid showed a more sluggish fall and was 0.09 of an inch higher than the mercurial. The passage of this storm has furnished some interesting features in connection with the ordinary aneroid barometers. Some aneroids which have been checked with the mercurial barometer in this office and found very accurate at ordinary pressures read much too low and others read too high during the passage of the hurricane. The Weather Bureau barometer at Burrwood shows a pressure of 29.00 inches at 8:30 a. m. on September 29, while the aneroid shows the lowest during the storm as 29.00 inches at 9:45 a. m. At New Orleans the barometer fell 0.33 inch during the hour just preceding the occurrence of the lowest pressure, but New Orleans was much nearer the center of the hurricane than Burrwood, and this explains why the fall in pressure was not so great at Burrwood as at New Orleans. Judging from the actions of the aneroid barometer on the U. S. dredge *New Orleans*, it is apparently safe to assume that the lowest barometer at Burrwood was about 28.80 inches. The relation of Burrwood to the center of the hurricane will be taken up later.

The barometer readings given in Table 4 were made at Morgan City, La. (67 miles west of New Orleans), and furnished by Mr. R. A. Squires, of Morgan's Louisiana & Texas Railroad & Steamship Co.

TABLE 4.—Readings of aneroid barometer at Morgan City, La.

[Correction, perhaps +0.02 inch.]

Time (90th M. S. T.).	Aneroid barom- eter.	Time.	Aneroid barom- eter.
<i>Sept. 29.</i>		<i>Sept. 29.</i>	
A. M.	Inches.	P. M.	Inches.
4:30.....	29.58	3:00.....	29.06
7:00.....	29.56	4:00.....	29.05
8:00.....	29.53	5:00.....	29.10
9:00.....	29.50	8:00.....	29.18
10:00.....	29.43	9:00.....	29.24
11:00.....	29.38	10:00.....	29.31
12:00, noon.....	29.30		
P. M.		A. M.	
1:00.....	29.20	3:00.....	29.50
2:00.....	29.10		

Mr. Squires reports that the wind blew hardest from a direction 2 to 4 points west of north about 4 p. m. to 4:30 p. m., and went to the west about 8:30 p. m. His barometer reads, at ordinary pressures, 0.02 inch lower than the Weather Bureau barometer at New Orleans.

The following barometer readings were taken at Bay St. Louis, Miss., and furnished by Prof. Florian Schaffter, of New Orleans, who was spending the summer at that place:

TABLE 5.—Readings of an aneroid barometer at Bay St. Louis, Miss., by F. Schaffter.

[Correction, see text.]

Time (90th M. S. T.).	Aneroid barom- eter.	Time.	Aneroid barom- eter.
<i>Sept. 29.</i>		<i>Sept. 29.</i>	
A. M.	Inches.	P. M.	Inches.
10:30.....	29.60	8:00.....	29.12
11:30.....	29.48	11:00.....	29.18
P. M.		A. M.	
3:00.....	29.34	1:45.....	29.26
6:00.....	29.14	8:00.....	29.52
		<i>Sept. 30.</i>	

Prof. Schaffter says that the lowest barometer occurred at 8:00 p. m. of the 29th and is represented by the reading given. The aneroid barometer he used is a good one, and at ordinary pressures it reads the same as the Weather Bureau mercurial barometer at New Orleans. I am of the opinion that a mercurial barometer at Bay St. Louis would have shown a pressure of about 28.90 inches. The actual readings given by the aneroid show a barometric gradient of 1 inch in 50 miles. Bay St. Louis, Miss., is east of and a little north of New Orleans.

The following table gives aneroid barometer readings during the hurricane, September 29, 1915, which were made in New Orleans at Stanley Thomas hall, Tulane University of Louisiana, by Prof. W. B. Gregory and Mr. N. C. Curtis:

TABLE 6.—Readings of an aneroid barometer at Tulane University, Sept. 29, 1915.

Time (90th M. S. T.).	Aneroid barom- eter.	Time.	Aneroid barom- eter.
A. M.	Inches.	P. M.	Inches.
8:30.....	29.60	2:15.....	29.10
9:05.....	29.55	2:30.....	29.05
9:30.....	29.52	2:35.....	29.02
10:30.....	29.45	2:40.....	29.01
10:50.....	29.38	2:45.....	29.00
11:00.....	29.40	3:00.....	28.97
11:15.....	29.36	3:10.....	28.95
11:30.....	29.30	3:15.....	28.93
12:00, noon.....	29.30	3:30.....	28.90
12:40.....	29.23	4:00.....	28.76
		4:30.....	28.65
P. M.		4:45.....	28.35
1:00.....	29.20	5:15.....	28.25
1:20.....	29.17	5:30.....	28.10
1:45.....	29.14	6:00.....	28.10

Tulane University is 7 miles west of the local office, Weather Bureau, and 1 mile north of the sugar experiment station; the grounds of Tulane University and Loyola University are adjacent, hence these records will be of value in connection with the wind directions reported from the sugar experiment station and from Loyola University.

WINDS.

The wind gradually increased during the afternoon and night of *September 28*, the prevailing direction being from the east and oscillating between northeast and southeast; the most frequent oscillations were toward the northeast. From midnight to 2:45 a. m. of the 29th; the wind was blowing steadily from the northeast with a velocity of from 17 to 18 miles per hour. From 2:45 to 8 a. m. the prevailing direction was east, oscillating occasionally between northeast and southeast; when the wind changed from northeast to east the velocity increased to 25 miles per hour, and a maximum velocity of 34 miles per hour occurred for a period of five minutes at 3:50 a. m. At 8 a. m. the wind backed to northeast and continued from that direction until 1:10 p. m.; from 1:10 p. m. to 4:15 p. m. the prevailing direction was east, oscillating at frequent intervals to the southeast; from 4:15 p. m. to 5:20 p. m. the prevailing direction was southeast, but there were intervals of three to five minutes with the direction from the east. From 5:20 p. m. to 6:30 p. m. the wind was steady from the southeast. The wind shifted from southeast to south at 6:35 p. m. and to southwest at 6:45 p. m., continuing from that direction during the night. The velocity now subsided rapidly, falling below 30 mis./hr. during the hour ending at 9 p. m.; however, maximum velocities of 32 to 36 miles were recorded in each hour from 11 p. m. of the 29th to 3 a. m. of the 30th.

TABLE 7.—Wind velocities and directions at weather bureau, New Orleans, La., Sept. 29, 1915.

Time.	Direction.	Mean velocity.	Maximum 5-min. velocity.
		Mis./hr. 17 to 18	Mis./hr.
Midnight (28)-2:45 a. m.....	NE.		
3:50 a. m.....	E.		34
2:45-8 a. m.....	E.; ne., se.	25	
7-8 a. m.....	E.	32	39
8-9 a. m.....	NE.	35	43
9-10 a. m.....	NE.	37	45
10-11 a. m.....	NE.	42	48
11-noon.....	NE.	40	53
Noon-1 p. m.....	NE.	48	54
1:10 p. m.....	e.		
1-2 p. m.....	E.; so.	49	54
2-3 p. m.....	E.	50	56
3-4 p. m.....	E.	50	54
4:15 p. m.....	SE.		
4-5 p. m.....	SE.	60	72
5-6 p. m.....	SE.	62	186
6:35 p. m.....	S.		
6:45 p. m.....	SW.		
6-7 p. m.....	SE., SW.	41	53
7-8 p. m.....	SW.		

1 E-SE.

The wind velocity was 50 mis./hr. or higher for four hours and was 60 or above for two hours, the maximum velocity, 86 mis./hr., was 20 miles in excess of the highest velocity, 66 miles, previously recorded at New Orleans. The wind attained the greatest velocity when it shifted from east to southeast. The wind subsided rapidly after 3 a. m. *September 30*, and died out almost completely between 5 p. m. and 8 p. m. The wind backed to the west at 8:45 a. m., and to the northwest at 1 p. m., *September 30*. The wind, when at its height, was not steady but

came in a rapid succession of gusts of a few seconds duration, which may be likened to pulsations. The extreme velocity of 130 miles per hour, from the southeast, occurred at 4:58 p. m., while the maximum velocity for five minutes, 86 miles per hour, occurred from 5:11 to 5:16 p. m. The velocity in the pulsating gusts of a few seconds duration was, at times, undoubtedly much greater than the extreme velocity for a whole single mile.

The wind velocity 50 miles distant from the center was evidently much greater than it was at New Orleans. At Burrwood, La., 100 miles south of New Orleans and located at the mouth of the southwest pass of the Mississippi delta, unprecedented high winds for this section of the country were recorded and the velocity exceeded any winds previously recorded on the Gulf coast. In fact, this was the most intense hurricane known to the recorded history of this part of the country. [The automatic record of the anemometer at Burrwood is unusually perfect and distinct, notably so when one considers the abnormally high winds it records; much credit is due G. E. Henderson, the observer, for having maintained his instrument in such perfect condition and for securing such a record.] The wind directions and velocities at Burrwood during September 29 are given below in Table 8.

TABLE 8.—Wind velocities and directions recorded by the Weather Bureau self-recorder at Burrwood, La., Sept. 29, 1915.

Time. (90th M. S. T.)	Direction.	Velocity.		
		Mean.	Maximum, 5 minutes.	Extreme, 1 mile.
		Miles/hr.	Miles/hr.	Miles/hr.
4:45 a. m.-7:20 p. m.	ene.	70+		
6 a. m.				
7 a. m.-6:35 p. m.	e. by n.	80+		
8 a. m.	e. by s.			
10 a. m.	ese.			
Noon.	se. by s.			
2 p. m.				
3-4 p. m.		108		
3:31-3:50 p. m.		116		
3:40-3:45 p. m.			124	
3:45 p. m.				140
4-5 p. m.		106		
5-6 p. m.		96		
6 p. m.	SW., S.			

At 6 p. m. of the 29th the wind went to southwest and was southwest or south the remainder of the night; by noon of the 30th it had settled into the southwest. Along the Gulf Coast, from Burrwood eastward to Rigolets, the wind velocity was probably about the same as at Burrwood. From Rigolets the wind probably decreased in velocity toward the center of the hurricane, and there was a rapid decline in the velocity to the eastward of the Rigolets.

Extracts from reports by cooperative observers.

The following extracts from special reports of Weather Bureau cooperative observers at stations in the area covered by the hurricane, furnish valuable material relative to wind changes with the progress of the hurricane. From these and other available material we can determine the exact route over which the center of the hurricane traveled. They also furnish valuable data concerning the conditions of the weather at the center of the hurricane, such as the "eye of the storm," calms, etc. The extracts are given in geographical order commencing on the Gulf coast and thence northward with the progressive movement of the hurricane.

Houma, La.—The wind blew from the northeast on September 29 until between 10 a. m., and 11 a. m., when it began blowing alternately north and northeast, with intermittent periods nearly calm. About 4 p. m. there was a lull, after which the wind blew its hardest from the northwest, finally falling off in that quarter between 11 p. m. and midnight; the wind went from northeast to north, northwest, and west.—*F. X. Zeringer.*

Lockport, La.—The wind began to increase Tuesday night (28th) shortly after dark, but its intensity was not noticed particularly until about 9 a. m. Wednesday, the 29th. During this time it was blowing from the northeast and continued from this quarter with increasing intensity until between 4:30 p. m. and 5 p. m., when it dropped very quickly to a moderate velocity. This lasted for about half to three quarters of an hour when it again began to blow hard from the northwest, or perhaps a little west of northwest. I did not notice any gradual change in the direction from the northeast to northwest, if there was any. There was no period of calm, my observation being that it had changed from a moderate and decreasing northeast wind to an increasing northwest gale. It was also my opinion that our greatest velocity was from the northwest, but lasted only for a very short period. Trees that had withstood the northeast wind snapped off with the northwest wind. By 8 p. m. the wind began to be more moderate.—*Frank H. Adams.*

Avoca Island near Morgan City, La.—After blowing northeast for some hours after the storm began on the morning of the 29th, the wind backed up north by northeast and blew as we estimate at the rate of about 50 miles per hour. It then backed farther and gradually to the north, and I should say blew directly from the north during the highest of the gale, or from about 4 p. m. to 6 p. m. During the night the wind shifted to the west by the way of northwest. We were afraid of a tidal wave here, and the writer noted particularly your wind forecast and saw your predictions verified.—*Eugene A. Pharr.*

Morgan City, La.—The wind was from the northeast the morning of the 29th and continued to increase from that direction until 1 p. m., when it shifted to north-northwest and still increased in velocity until 4:30 p. m., when it blew hardest. From this time until 8 p. m., the wind decreased and backed to the west. There was no period of calm.—*V. E. Kinsey.*

Sugar Experiment Station, New Orleans, La. (7 miles west of local office, Weather Bureau).—During the early hours of the morning of the 29th the wind direction was very uncertain, but as the gale increased it blew more or less north-northeast; toward evening, from about 4 p. m. to 5:30 p. m., the wind had reached its greatest velocity, and it seemed to come directly from the northeast. At 4:50 p. m. it did its worst damage to the station. All during the day there were lulls for a few seconds and then renewed gusts of wind and rain.

Loyola University, New Orleans, La. (1 mile north of the Sugar Experiment Station).—From early morning until about 5:15 to 5:30 p. m., the wind seemed to be steady from the northeast. From 5:30 p. m., until about 6:30 p. m., or perhaps a little later, there was almost a perfect lull, at least it seemed so by comparison with the tremendous disturbance preceding. At the time between 6:30 p. m. and 7 p. m. the wind veered around until it blew strong from a southerly direction, it being difficult to say whether it was from the south, southeast, or southwest.—*Anton L. Kunkel, S. J.*

Reserve, La.—During the recent hurricane the wind shifted from northeast to east, predominating from the northeast. The storm started here about 10 a. m., and blew steadily from the northeast until about 6 p. m., then from that hour it shifted from northeast to east until about midnight; after midnight it turned to the west for quite a time. During the storm there was no period of calm, but the wind blew in gusts most of the time.—*Edward Godchaux.*

St. Gabriel, La.—The wind began from the northeast about 7 a. m. of the 29th, and gradually increased until 9:30 p. m., when it shifted to the northwest and subsided.—*Capt. John B. Murphy.*

Donaldsonville, La.—The direction of the wind in the hurricane of September 29 was northeast from the time of observation at 7 a. m. until 5:30 p. m., when there was a period of calm, after which the wind shifted to north, keeping that direction until 8:45 p. m., when it backed to northwest.—*Alfred J. Landry.*

Cinclare, La.—The wind on September 29 was from the northeast until about 5 p. m., when it shifted to the north and remained from that direction until it subsided. The wind was high from noon until 11 p. m. There was no noticeable period of calm.—*A. W. Wallace.*

Covington, La.—High east wind began on the morning of the 29th; about 6 p. m. the wind increased in velocity and commenced from a southeasterly direction. The velocity increased from 7 p. m. until 10 p. m., when it blew hardest. After the wind shifted to southeast there were lulls of a short duration, then the wind would blow with greater fury than ever.—*Mrs. M. C. Buquoi.*

Baton Rouge, La.—On the morning of September 29 there was a light northeast wind, which increased in velocity as the day passed, and between 5 p. m. and 6 p. m. it shifted to northwest, and about 7:30 p. m. the wind was highest.—*Elmo M. Bott.*

Hammond, La.—The wind started in blowing from the northeast in the morning and gradually increased in velocity as night approached. About 5 p. m. it lulled slightly, but then began to blow harder until about 7 p. m., when it came out of the north, and about this time the storm seemed to reach its maximum.—*C. C. Carr.*

Amite, La.—The winds came alternately high and light from the same direction, northeast. There were high winds from the northwest also.—*Miss Lulu M. Wentz.*

SPECIAL FEATURES SHOWN BY THE WINDS.

An interesting feature brought out by the foregoing reports on the winds in this hurricane is that in the eastern or right-hand segment of the hurricane the highest velocities are invariably reported to have occurred with the change from easterly to southeasterly winds, being as a rule from the southeast, and probably coincident with the passage of the hurricane center. The records at New Orleans and Burrwood show this positively. In the western or left-hand segment, the highest velocities are reported to have occurred at some point between north and northwest, and with a change of the winds towards the west. The highest winds in the right hand segment came from the opposite quadrant from that in which they occurred in the left-hand segment, being almost from directly opposite directions.

At New Orleans with the change in direction from southeast to south the wind velocity fell off to 50 per cent of what it had been with the same barometric gradient when the direction was from the northeast to southeast. A similar decrease in velocity is reported to have taken place in the western or left-hand segment of the

hurricane when the wind shifted from northwest to west and southwest. The progressive movement of the hurricane being about 12 miles per hour (see path and movement of hurricane center) accounts for part of this, viz: The progressive movement would increase the gradient wind by 12 miles per hour in the front segment, and diminish the gradient wind by the same amount in the rear segment, which together would give an apparent difference in velocity, making it 24 miles greater in the front segment than in the rear segment of the cyclonic area. This leaves a falling off in the wind velocity in the rear segment below that in the front segment when compared to barometric gradients of something like 10 miles per hour, which is not explained by the progressive velocity of the cyclonic area.

PRECIPITATION.

Light precipitation began at 2:35 a. m., on the 29th, and with the exception of a heavy shower for a few minutes about 3:40 a. m., soon after the wind veered from northeast to east, very little precipitation occurred prior to 7 a. m., during which time the wind was from the east. Soon after 7 a. m., the wind backed to the northeast and the precipitation increased until 12 noon, 1.59 inches being recorded in the hour ended at 12 noon. The precipitation became lighter again after the wind veered to the east at 1:10 p. m., and it diminished until the fall during the hour ending at 3 p. m., was only 0.30 inch. As the wind veered toward the southeast the precipitation became heavier again and during the hour ended at 5 p. m., also the hour in which the complete change from east to southeast occurred, the precipitation amounted to 1.05 inches. The precipitation then diminished and almost ceased about half an hour before the wind veered from southeast to south at 6:35 p. m., or rather it ceased during the hour in which the change to south was taking place. A light misting rain, however, continued until 11:30 p. m. The total precipitation during the passage of the hurricane amounted to 8.20 inches. A notable feature in connection with the precipitation was the increase in precipitation just prior to the time that the wind shifted from northeast to east near the middle of the day, the falling off in the amount of precipitation both during the early morning hours and again in the afternoon hours during the time the wind was from the east, the increase in the amount of precipitation again as the wind was shifting from the east to southeast, and that the precipitation almost ceased when the wind veered from southeast to south.

The distribution of the precipitation in the area covered by the cyclonic movement of the atmosphere is of special interest. The heaviest precipitation occurred near the center and within a distance of 25 miles to the east of the center, but heavy precipitation occurred over a large area in the eastern segment of the storm, while to the west of the path of the center of the storm the precipitation diminished rapidly and 50 miles to the west of the path of the center of the storm the precipitation was negligible. The distribution of precipitation in relation to the center of the hurricane is shown in figure 7 (XLIII-114).

LIGHTNING AND THUNDER.

The flashes of lightning, supposed to be a special feature in a tropical hurricane, were not present in this one. There was an absence of lightning and thunder, which calls for special comment. About 3 a. m. of September 29 faint sheet lightning was observed a few times in the

northeast, and twice low, distant thunder was heard, but after that time and during the passage of the hurricane the total absence of lightning was commented on in the office. About 9:30 p. m., September 29, four hours after the center of the hurricane had passed, Mr. A. V. Hall, of the Times-Picayune, reported he had observed a peculiar lightning in the southwest a few times. Mr. Hall described it as a light flaring up in sheets not unlike the fire coming out of the mouths of serpents as represented in imaginary illustrations.

NOTE.—In the hurricane of September 8, 1900, at Galveston, Tex., I do not remember to what extent lightning was visible during the day, but certain incidents were revealed by lightning at night which I can never forget. It was sheet lightning to the southeast that revealed to me out of the darkness after the wrecking of my home my brother and my two oldest children floating on wreckage. The lightning enabled me to pick up a strange child about 4 years old floating on the debris of a wrecked house, and occasional flares of lightning enabled us to see buildings, which we would soon hear being ground down and destroyed by the waves and wreckage on which we were floating. This lightning occurred while the wind was from the southeast and ceased quite a while before we landed at 11:30 p. m. In my report on the hurricane of September 8, 1900, I did not go into details relative to meteorological conditions, and I give this here in order to put it of record.

TEMPERATURE.

As the hurricane approached during the night of the 28th, the temperature fell suddenly about 3:40 a. m. of the 29th from 81°F. to 75°, but this occurred with the first heavy shower of rain preceding the hurricane, and the temperature always shows a sudden and decided drop with a heavy shower of rain. After 3:40 a. m. the temperature fell gradually 1 or 2 degrees until noon of the 29th, fluctuating considerably. During the afternoon of the 29th, the sudden fluctuations disappeared, and there were gradual rises or falls of 2 or 3 degrees, the falls occurring with sudden downpours of precipitation and the rises when these would slacken. Temperature conditions during the hurricane were not unlike those found in ordinary heavy rainstorms.

PATH AND MOVEMENT OF HURRICANE CENTER.

The pressure and wind records at New Orleans, Burrwood, and Morgan City, La., Bay St. Louis, Miss., and other places, especially the fact that the barometer remained nearly stationary at Burrwood from 9:45 a. m., the time of the occurrence of the lowest barometer, until 2 p. m. of the 29th, more than four hours, taken along with the wind reports from surrounding stations, indicates that the storm center struck the Louisiana coast about halfway between the mouth of the Mississippi River and Atchafalaya Bay, the center being then about 50 miles west of Burrwood and recurving slowly toward the northeast. The slight change in pressure conditions at Mobile and Pensacola from 8 p. m. of the 28th to 8 a. m. of the 29th also shows that the storm recurved over southeastern Louisiana, and was probably moving toward the northwest up to the time that its northern segment struck the marshes of southeastern Louisiana. The storm center passed near and east of La Rose and Lockport on Bayou Lafourche, where the wind backed suddenly without an intermediate direction from northeast to northwest during the afternoon of the 29th. At Thibodaux, in the northwestern part of Lafourche Parish, the wind backed more gradually from northeast to northwest and west. The prevailing wind at New Orleans being northeast from 8 a. m. until 1 p. m., five hours, east from 1 p. m. until 4 p. m., three hours, southeast from 4 p. m.

until 7 p. m., three hours, then southerly the remainder of the day, indicates that the storm curved to the north-eastward around New Orleans.

The lowest pressure at Morgan City, La., 67 miles west of New Orleans, was 29.05 inches and the lowest at Bay St. Louis, Miss., 50 miles east of New Orleans, was 29.12 inches. The gradient between Bay St. Louis and New Orleans, when applied from Morgan City eastward to the path of the center of the hurricane, would bring the 28.11 inches isobar on the west side of the center to within about 25 miles of the local office, Weather Bureau, New Orleans. This would place the center of the hurricane about 12 miles to the west of the New Orleans office. This is also in harmony with the reports of changes in wind direction at the sugar experiment station and Loyola University, just 7 miles west of the local office, Weather Bureau, where the wind was reported by two trained independent observers, 1 mile apart, as shifting from northeast to southeast without any intermediate direction. Further, a complete calm, with the wind shifting from northeast to southeast without any intermediate direction was reported by Mr. C. E. Heckathorn, observer, Weather Bureau, as occurring at his residence from 5:30 to 6 p. m., 1 mile farther west than the above stations, indicates that the eastern limit of the imaginary center, or calm area of the hurricane, passed about 8 miles west of the local office, Weather Bureau, and that the diameter of the comparatively calm area was about 8 miles. The barometer reading at New Orleans probably represented as low a barometer as occurred at any point, even in the center of the hurricane. At Tulane University the barometer at 20 feet altitude was 28.10 inches for 30 minutes and another barometer nearby read 28.09 at 5:42 p. m.

The diameter of the hurricane proper—that is, between points where the pressure was 29.50 inches on the outer rim (this pressure is taken as the outer rim because this hurricane occurred within an area of low pressure of unusually large extent)—may safely be placed at between 250 and 300 miles. The time required for the passage at New Orleans from the front isobar of 29.50 to the rear isobar of 29.50 inches was about 24 hours, which would make the progressive movement of the hurricane about 12 miles per hour. Mobile, Ala., 150 miles east of New Orleans, was on the outer rim of the hurricane proper. The lowest barometer reading reported from the Mobile station was 29.50 inches, and it is assumed that a similar pressure would have been noted about 150 miles west of New Orleans. No observer reports a breaking away of clouds in the center, “the eye,” of the storm.

Figure 6 (XLIII-114) gives the directions in which the winds changed at several stations in southeastern Louisiana during the progress of the hurricane, and shows as accurately as possible, from the information available, the path traversed by the center of the hurricane.

TIDE CONDITIONS.

No extraordinary tide conditions appeared during September 28, the day preceding the hurricane, and as late as the morning of the 29th men who had been advised on the afternoon of the 28th to go to their families on the Mississippi coast returned to New Orleans on an early train Wednesday morning and telephoned me that they had left everything comparatively quiet on the Gulf coast and they had noticed no extraordinary tide on the trip to New Orleans. On my advice they attempted

to return to their families by the first train at 11 a. m., but an unusually rapid rise in the tide had submerged the tracks of the Louisville & Nashville Railroad at Rigolets, and the train was annulled. The tide continued to rise as the hurricane advanced and during the afternoon of the 29th covered all low lying lands south of New Orleans and east nearly to Bay St. Louis and around Lake Ponchartrain to the north. The tide and swells topped the levees along the Mississippi River below New Orleans and in places the tide was reported to be as much as 15 to 20 feet above sea level. It was undoubtedly the highest tide of record in this section. At the junction of Harveys Canal with the Mississippi River, just above New Orleans, and 100 miles from the Gulf, the tide was 6 feet in the river. Swells rolled up the river during the hurricane 10 to 12 feet above the high tide. The water was carried into Lake Ponchartrain by the storm, overflowed the protection levees, and flooded a large area in the western part of New Orleans. Over that portion of the city lying between the Old Basin Canal and Broadway and from Claiborne Avenue out to Lake Ponchartrain, the water driven in by the storm ranged from 1 to 8 feet in depth. After the passage of the storm center the tide receded rapidly, except in New Orleans where the water had to be removed by the drainage system and remained for three or four days.

It is evident that the tide came up with the hurricane, because, considering the northeast winds blowing, there were no extraordinary tide conditions, even as late as the morning of the 29th. The long swell on the ocean usually reported as preceding hurricanes had not been observed up to that time. The only noticeable conditions indicating the advance of the hurricane and its probable course was a wind-blown rise of 1 foot in the Mississippi River at New Orleans, and a fall of 0.5 foot in the Atchafalaya River at Morgan City. Had it not been for the fall in the tide at Morgan City there would have been nothing in tide conditions along the coast to attract attention, with the character of winds prevailing.

WARNING SERVICE AND ACTION TAKEN TO PROTECT LIFE AND PROPERTY.

Warnings announcing the appearance of the hurricane in the eastern portion of the Caribbean Sea were received at New Orleans on September 23, and advisory warnings were received daily thereafter until the passage of the hurricane. These warnings gave the location of the storm and its probable direction of movement, and were telegraphed to all coast stations, radiographed to ships at sea, telephoned to ship agents, and published in the daily papers.

September 28 the following warning was distributed by telegraph to all display stations on the Louisiana coast, radiographed to ships at sea, and was widely distributed by telephone and mail:

Hoist northeast storm warning, Louisiana coast, 8:30 a. m. Tropical disturbance will cause increasing northeast winds and probably moderate gales along the Louisiana coast this afternoon and to-night.
(Signed) CLINE.

Warnings for moderate gales were sent with the forecasts at 8:20 a. m. to all telephone exchanges in southern Louisiana. At 9:50 a. m. the following advisory warning was received from the central office, and was distributed by telegraph to all display stations on the coast, radiographed to ships at sea, and telephoned to all interests likely to be affected:

Advisory storm warning. Tropical storm attended by dangerous winds centered this morning over Gulf of Mexico in apparently latitude

24° and longitude 87° and moving northward toward the mouth of the Mississippi River. Its influence will be felt late to-night and Wednesday on the middle Gulf coast.

(Signed) BOWIE.

About 1:30 p. m. the following message was received:

BERWICK, LA., September 28, 1915.

Dr. I. M. CLINE,
Weather Bureau, New Orleans, La.

This company has men and boats on the Gulf and we would appreciate advice sent us direct at our expense if storm should head this way.
(Signed) LOUISIANA OYSTER & FISH Co.

The following reply was sent at once:

Hurricane centered about 300 miles off mouth of Mississippi River apparently moving northward. Consider it advisable to call in men and boats. Effects of storm will be felt on middle Gulf coast by Wednesday morning.

(Signed) CLINE.

At 2:40 p. m. the following hurricane warning was received from the central office, Washington, D. C.:

Hoist hurricane warnings 3 p. m., New Orleans to Pensacola. Tropical storm centered near latitude 26° and longitude 88°, moving northward. Dangerous winds late to-night and Wednesday. Center of storm will probably strike coast near or immediately east of the mouth of the Mississippi River. Advise all interests.

(Signed) BOWIE.

An extraordinary distribution of warnings was commenced at once and the following injunction was given those to whom it was sent: "Please reach persons in exposed localities." It was telegraphed to all special storm warning display stations on the middle Gulf coast; was telephoned at Government expense to the telephone exchanges in the threatened area in Louisiana. Mr. T. Barton Baird, district manager of the Cumberland Telephone & Telegraph Co., was called up, the warning read to him, and a list of the telephone exchanges to which the warning had been sent; by our request he instructed the managers at the several exchanges to give the warnings the greatest possible distribution and to endeavor to reach persons in exposed localities. Similar action was taken by Mr. W. A. Porteous, manager of the Western Union Telegraph Co.; Mr. N. E. Church, manager of the Postal Telegraph Co.; Mr. Charles Marshall, superintendent of the Louisville & Nashville Railroad; and by Mr. Isidore Fisher, at Fishers Landing on Harveys Canal, who sent the warning by boat at Government expense down through the Barataria section to Grand Isle. Mr. J. R. Reynolds, superintendent of police, New Orleans, was requested to post the warnings at each police station, and to notify the people on the police rounds that a hurricane with dangerous winds would prevail Wednesday; to advise the people to exercise every precaution against danger; and to reach persons in exposed localities. The fire-alarm department, at my request, sent the warning to all their stations with similar instructions. The commanding officers at Jackson Barracks and at the naval station took similar action. An assistant at the Weather Bureau office telephone, with a list of shipping and others who receive such warnings, called up the chief operator at the telephone exchange and had a special operator assigned to switching from one number to another so that we could get the warning to the greatest number in the shortest time.

The pressure conditions around the Gulf coast Tuesday morning, September 28, and cloud conditions and movements during the day were such that public interests were advised that afternoon that the hurricane would probably be more severe than that of 1909, the most severe storm in the previous history of New Orleans.

Capt. Galbraith, manager of the Western Union branch in the New Orleans local office, Weather Bureau, reported for duty shortly before 7 a. m., September 29. I informed him that wire trouble would soon be experienced and requested him to take such precautions as would enable us to collect reports and get out forecasts and warnings and distribute them early. The following warning, based on pressure and weather conditions along the Gulf coast and on tide conditions at New Orleans and Morgan City, La., was issued at once:

Advisory warning Louisiana coast, 8:20 a. m. Tropical disturbance will move northward over southeast Louisiana. Center will probably pass between New Orleans and Atchafalaya Bay. Easterly gales probably reaching hurricane force in eastern Louisiana and strong northerly winds to moderate gales on west Louisiana coast to-day and to-night. High tides.

(Signed) CLINE.

This warning was given the widest possible distribution by telephone, telegraph, and railroad offices throughout the threatened area and also by mail in New Orleans. Warnings for easterly gales and probably hurricane winds were telephoned to all eastern Louisiana, and for northerly to westerly gales to all western Louisiana. We had just finished distributing forecasts and warnings by telegraph and telephone at 9 a. m. when serious wire trouble set in.

All persons asking were advised to remain at home and stay indoors; the principals of several schools were also advised.

This advice and the distribution of the warnings through the police and fire-alarm departments kept people at home or in their offices and stores and reduced the number of people on the streets during the storm to a minimum, and this unquestionably prevented much loss of life in New Orleans.

When the barometer fell below 28.25 inches and continued falling so rapidly, I began wondering what the result would be. It was a great relief to us when the barograph pen stopped at a *reduced barometer reading of 28.11 inches* and then began to rise. Every minute during the afternoon of the 29th I had told people coming into the office and over the telephone, that the worst was not over; but after 5:50 p. m., they could be told that the center had passed although dangerous winds would continue for a few hours. Telephone calls came so fast that when we wished to send a message we could not get central and had to go to another telephone. Some one was on the line before we could hang up and lift off the receiver. The strain of anxiety on the part of the public was the greatest I have ever witnessed.

The Daily States, September 30, 1915, in commenting on the storm says:

When the fierce blasts, which in the morning hours came from the northeast, shifted east, then south, and finally, about 10 p. m. southwest, were at their most terrifying height in the late afternoon, hundreds of persons, women, children, and men fought their way through the swirling, blinding mist of rain and flying fragments of roofs and cornices to the substantial stone and marble post-office building in Camp Street, in the top story of which the Weather Bureau is located. Here they felt safer and could get some first-hand information as to what to expect. Among them were some 20 women who lived in the Christian Women's Exchange, the roof of which had already been damaged.

When night came and word still came from the Weather Bureau that, though the center of the storm had passed about 6 o'clock, all danger was not yet over, more than 300 women, children, and men decided to remain in the building all night. Toward midnight, exhausted with anxiety, many of them laid (!) down on the stone floor of the post-office corridor, their heads pillowed on mail sacks supplied them by Assistant Postmaster George V. Fuchs, and snatched such sleep as they might under these hard conditions.

Not until daylight did they leave for their homes.

From many office buildings and stores down town telephone messages came into the Weather Bureau at nightfall asking whether it was safe for other crowds of men and women gathered in them to venture into the streets to go home, but in every case the bureau advised that they remain where they were until daylight on account of darkness and fallen wires.

About 11 a. m., September 29, the chief clerk to the superintendent of the New Orleans & Northeastern Railroad called and asked advice about taking trains over the fourteen miles of trestle and abutments across Lake Ponchartrain. They were advised to suspend trains as the storm would increase in severity during the afternoon. The wind subsided slightly between 1 p. m. and 2 p. m., and the officials of the railroad, being anxious to keep up their train schedules, called again and asked if it would not be safe for them to keep their trains moving. I told them positively that higher winds would occur than had been recorded and that in my opinion there would be winds which would blow trains off the trestle, and they then issued orders for the trains coming in to New Orleans to stop at Slidell on the other side of the lake and they canceled all outgoing trains.

Special observations were telegraphed to the central office every two hours during the hurricane, up to and including 3 p. m. At 5 p. m. all wires out of the city had gone down. Efforts were made to communicate with the Naval radio station in Algiers, the Tropical radio station, and the Marconi station, but all were cut off or out of commission, and New Orleans was absolutely cut off from the outside world. About 10 p. m. of the 29th Mr. Israel, manager of the Associated Press, telephoned that the Marconi Co. had rigged up a temporary wireless station on the American steamship *Excelsior* at the foot of Saint Ann Street, and that they would relay important matter through the American steamship *Creole*, at anchor near the mouth of the river, to Mobile, where it would be put on the land lines. A message to the Chief of the Weather Bureau, giving the regular 8 p. m. observation of the 29th and a brief report on the hurricane was thus sent from New Orleans about 11 p. m. of the 29th. [This message was received at Washington during the afternoon of the 30th]. The regular observations were sent and special reports were transmitted to the chief of the bureau daily through the above channels until October 2, when wire service was established by the Western Union Telegraph Co. into the local office of the Weather Bureau.

The warnings reached every locality in the threatened area, as is shown by press reports and other reports from the storm area, except that the water became so rough that the boat chartered could not make the trip to Grand Isle; however, the previous notices relative to the movements of the storm reached Grand Isle.

People in exposed localities, with a few exceptions, acted promptly on receipt of the warning and sought places where they thought they would be secure. Grand Isle and the Barataria Bay section is practically devastated, nearly all buildings having been destroyed, and all live stock drowned. However, only 23 lives were lost in all this vast region, and 14 of these resulted from the capsizing of boats. At Burrwood the inhabitants went aboard the United States dredge *Benyuard*; fishing boats and other small craft sought refuge in bays and bayous, where they felt secure, but the storm tide of 15 to 20 feet carried many of them from their moorings and left them high and dry on the prairies or far out in the marshes. Weather Bureau warnings held at least 25 ocean-going steamers in the river and at the wharves from the 24th

to 30th. Without definite advice regarding the hurricane the effects on shipping in port would have been disastrous. Vessels which went to sea on the 23d to 26th received the warnings and steered to the westward of the hurricane; no report of an ocean-going vessel being lost has been received.

DAMAGE AND LOSS OF HUMAN LIFE.

The damage to property and the loss of human life were remarkably small when the intensity of the hurricane is taken into consideration. In New Orleans several buildings were totally destroyed and nearly every building suffered injury to some extent, amounting in some cases to several thousand dollars. Four small steamers, or tugs, were sunk in the harbor and several steamers broke from their moorings and were blown ashore. A great many small craft which had sought refuge in the bays and bayous were blown ashore and left by the tide on dry land; several coal barges loaded with coal were sunk. The destruction of buildings was very great in the country surrounding New Orleans. At Leeville on the lower Lafourche, of the 100 houses in the village, only one was left standing, but no one was killed. At Golden Meadow and from that point to Cut Off, 100 houses were demolished, but no lives reported lost. At several places on the Mississippi River below New Orleans and on Lake Ponchartrain 90 per cent of the buildings were completely destroyed.

I have checked the deaths closely and 275 will cover the entire loss of life resulting from this unprecedented hurricane. The loss of life at Rigolets resulted from an absolute disregard of specific warnings and advice to come to New Orleans. Mr. John T. Meehan, of the Times-Picayune, was in the local office, Weather Bureau, when we issued the specific warning at 8:20 a. m., September 29, giving the path which the hurricane would follow and advising that hurricane winds and high tides would prevail over southeastern Louisiana that day and night. He asked me what the result would be at Rigolets, stating that he knew some people there, and I told him he had better telephone them at once, which he did. He spoke with Manuel, the keeper of the club, through his wife, gave him the warning and told him to have everybody come to New Orleans on the next train, which was due to pass that place about 10 a. m. Manuel replied that the train would not stop for them, and Mr. Meehan told him that if the train would not come to a stop for flagging to put a cross tie on the track. The keeper said, "They will put me in jail," to which Mr. Meehan replied, "You would be better off in jail than where you are now and for God's sake stop that train at all hazards and come to New Orleans." It has since been learned that Manuel flagged the train and it stopped, but the people were not there to get aboard, the rising tide was jeopardizing the passengers on the train, which could not wait until the people could be collected from the houses. Manuel returned to his companions and when the storm was over his lifeless body, with 23 others of those who were in the club, were found strewn over the marshes. Mr. Meehan, who went to the Rigolets the morning after the hurricane, with a rescue party, assisted in looking after the burial of the keeper, Manuel, and his companions.

Mr. J. B. Fasterling, Buras, La., president of the Plaquemines police jury, under date of October 1, says:

It is yet impossible to estimate the number of those who perished, but the death rate has been remarkably low considering the force of the storm. There were 2 feet more water than in the 1903 gale.

The Times-Picayune, October 3, says:

It generally is agreed that the death toll paid the hurricane has been remarkably low along the lower river compared to what the might of the gale led all to anticipate.

The damage done by the hurricane on the middle Gulf coast will probably exceed \$13,000,000, and approximately may be distributed as follows: In the city of New Orleans the damage has been heavy. The damage to municipal property has been appraised at nearly \$500,000. As late as October 13, more than two weeks after the hurricane, the Dealers and Contractors Exchange stated that a survey of the city indicated that 25,000 houses were then in a leaky condition as a result of the hurricane. The total damage to property in New Orleans may be safely estimated as at least ten times the amount of damage suffered by the public buildings belonging to the municipality, and on this basis the damage to property in New Orleans is placed at about \$5,000,000; to shipping and coal interests on the river, \$1,750,000; in the country outside of New Orleans, to buildings, railroads, small craft, crops, and telegraph and telephone systems about \$6,500,000.

VALUE OF WARNINGS IN SAVING LIFE AND PROPERTY.

Much of the success obtained through the warnings in saving human life and property was brought about by the specific statements given on the morning of Tuesday the 28th as to where the hurricane would strike the Gulf coast, and the forecasting Wednesday morning at 8:20 a. m. of the exact course its center would follow, with the character of winds and tides which would prevail, and by the firm and convincing manner in which the people were told what to expect and what to do. We expressed no doubts, but told the people specifically what to expect and advised them without hesitation what action to take. The admonition "Please reach persons in exposed localities," given to every manager of a telegraph and railroad station on the middle Gulf coast, and all telephone stations in southeastern Louisiana and others, with the hurricane warning on the 28th, impressed the people with the seriousness of the impending crisis, and stirred the public to prompt and decisive action to protect life and property such as was never exercised previously. The fact that only 275 lives were lost in all that vast stretch of 300 miles of coast line, including the most populous center in the South, tells the story of the value of the service rendered the people of this section.

The Times-Picayune, Thursday, September 30, 1915, says:

The intensity of the storm, while it did considerable damage in New Orleans and vicinity, proved the worthiness of Dr. I. M. Cline, the district forecaster of the United States Weather Bureau. Never before, perhaps, in the history of the Weather Bureau, have such general warnings been disseminated as were sent out by the local bureau in reference to the disturbance that passed New Orleans Wednesday evening. At 7 o'clock Wednesday morning Dr. Cline said the wind would attain a velocity of 65 miles an hour, or more. At 2 o'clock in the afternoon, when a velocity of 62 miles an hour had been recorded, and when most persons believed the worst had passed, Dr. Cline said the worst was yet to come. He then predicted that the maximum intensity of the storm would be reached here "between 5 and 6 o'clock." As a matter of actual record, the maximum was at 5:30, when a wind velocity of 86 miles an hour for 10 minutes was recorded, and when, for a period of about 20 seconds a velocity of 130 miles was reached.

There may have been much life loss along the coast, but such a catastrophe can not be charged to the Weather Bureau, for the warnings of the approach of the hurricane were sent broadcast before the high winds ever reached the Louisiana coast.

Tuesday afternoon Dr. Cline expressed the belief that the storm would be more intense than that which wrought such damage at New Orleans and along the coast in September, 1909. His prediction came true, although there were many persons in the city who were skeptical

concerning this prediction until the winds actually had recorded a new velocity record for the city.

The New Orleans Item, October 13, 1915, says:

About 20 years ago a West Indian hurricane, far lighter in force and stress than the recent storm, struck the Gulf coast. Over 2,000 lives were lost and many millions in property.

Ten days ago another West Indian hurricane came with tremendously increased intensity. But the loss in life in all the vast stretch of marsh and bayou and sea line is only 275. The property damage is infinitely less.

There is one specific reason for this difference in results: Increased efficiency in the Weather Bureau and an increased and extended service rendered possible by enlarged personnel and extended range of observations.

The News and Courier (Charleston, S. C., Oct. 1, 1915) published the following comment on the Weather Bureau's services:

WEATHER BUREAU MAKES GOOD AGAIN.

For the third time this season [fall of 1915] the United States Weather Bureau has been put to the test and for the third time it has proved its worth. Three great tropical storms have swept upon the shores of this country out of the southern waters where these tempests are brewed. But for the Weather Bureau's good work it is certain that each of these storms would have blotted out thousands of lives along the coasts of the Gulf States.

The News and Courier has already made acknowledgment of its realization of how fine the bureau's work has been. Now that for the third time this year the bureau has been put to the test and has met it admirably, a further acknowledgment is due. Seldom, if ever before, has the bureau been confronted with more important problems than those which it has met and solved this year, and this latest demonstration of its efficiency should not be allowed to pass without remark.

CONDENSATION UPON AND EVAPORATION FROM A SNOW SURFACE.¹

By B. ROLF.

[Reprinted from Science Abstracts, Sec. A, Sept. 25, 1915, § 1203.]

The following experiments were carried out in Swedish Lapland. Four shallow zinc trays, each about 600 square centimeters in area and 3 centimeters in depth, containing snow, were exposed in the open upon the snow-covered ground in such a way that their rims were level with the general surface of the snow. The trays were carefully filled with snow before each experiment and weighed. They were again weighed after an exposure of 24 hours in winter, or 12, 6, 3, or even 2 hours in summer. The difference in weight gives the gain or loss by condensation or evaporation. The experiments were carried out uninterruptedly from December, 1905, to July, 1906, but most of the results could not be used, being vitiated by disturbing causes. Of these, drifting snow was the principal in winter, and absorption of solar radiation by the trays was common in summer, producing an excess of melting and evaporation. The results of the experiments which were finally accepted as trustworthy are printed in full. In winter, and up to the beginning of June, the ground was completely covered with snow, but afterwards numerous bare patches were rapidly developed, and by the middle of July the snow had disappeared. Before June, water vapor therefore passed between the air and a snow surface; afterwards humid soil enters also into the process.

It is found that when snow covers the ground the condensation, C , can be connected with the duration of exposure in hours, t , the maximum vapor pressure at the temperature of the snow layer, f , and the actual vapor-pressure of the surrounding air, F , by the formula

$$C = at + b(F - f)t,$$

where a and b are constants which are determined from the observations by the method of least squares. A negative value of C indicates an evaporation instead of a condensation. In winter a is practically zero, and the formula is

$$C = +0.0174(F - f)t.$$

In spring, when the air temperature is above 0°C ., and the snow still covers the ground, f is the saturation of vapor-pressure at 0°C ., and is therefore constant (4.6 mm. of mercury). The formula becomes

$$C = -0.0010t + 0.0168(F - 4.6)t.$$

The cases when the ground is only partially covered could not be expressed by a similar formula, but it was found that by grouping the experiments according to time of day, values of a and b could be computed for each group and these values showed a marked diurnal variation. Thus in the morning a was $+0.009$; it reached a maximum of $+0.020$ in the afternoon, and fell off again in the evening and night. The constant b also showed a maximum during the day hours of about $+0.029$ and a minimum during the night of $+0.016$. The errors resulting from the use of these formulas are small in comparison with the amount of condensation or evaporation.—*R. Corless.*

RELATION BETWEEN MONTHLY VALUES OF ATMOSPHERIC PRESSURE VARIATION AND SIMULTANEOUS MONTHLY VALUES OF TEMPERATURE VARIATION AND HUMIDITY, AND GEOGRAPHICAL LATITUDE.¹

By N. EKHOLM.

[Reprinted from Science Abstracts, Sec. A, Sept. 25, 1915, § 1202.]

Köppen has considered the relation between pressure variation and the latitude of the observing station, the "deflecting force of the earth's rotation," and the friction between air and earth; but as the energy of all atmospheric motions can ultimately be expressed in terms of temperature and humidity, the author endeavors to discover a relation between pressure variation on the one hand and temperature variation, humidity, and latitude of observing station on the other. Hann had already found that temperature variations alone can not account for the observed pressure variations.

The investigation refers to the three winter months, December to February only, and the data used are monthly values from 23 stations between latitudes 50°N . and 70°N . If L is mean monthly pressure variation, W the simultaneous temperature variation, and F the simultaneous mean vapor pressure for a station of which the latitude is ϕ , it is found that the equation

$$L = 8.73 \sin^2 \phi F + 1.07 \sin^2 \phi W$$

expresses with considerable accuracy the dependence of L upon ϕ and W . The equation applies both to continental stations where F is small and W is large, and to maritime stations where F is large and W is small. Thus the values of the two terms on the right-hand side of the equation for the two stations Yakutsk (Siberia) and Valencia (southwestern Ireland) are respectively 0.88, 28.01, and 34.86, 8.69. The computed values of L are therefore 28.9 and 43.5, which differ from the actual values by 1.4 and 2.1.—*R. Corless.*

¹ See Ark. f. Mat., astron. och fysik, Stockholm, 1914, 9; 35. p. 1-19.

¹ See Ark. f. Mat., astron. och fysik, Stockholm, 1914, 10; 3. p. 1-11.

CLIMATIC SUBDIVISIONS OF THE UNITED STATES.¹

By Prof. ROBERT DE C. WARD.

[Dated: Harvard University, Cambridge, Mass.]

In dealing with the climatology of an area as large as that of the United States, we must, if our discussion be clear and systematic, adopt some scheme of subdivision into climatic districts, or provinces. Many suggestions have already been made along this line, and Mr. W. L. G. Joerg has recently done a useful piece of work in bringing together reproductions of the most important classifications of the "natural regions" or provinces of North America and of the United States.² Twenty-one different schemes are presented. Eight are grouped as *structural*, 4 as *climatic*, 2 as *vegetational*, 1 as *zoogeographic*, and 6 as *natural regions*. In addition, Mr. Joerg gives a new classification in which he has selected what seems to him best in the others.

Of the climatic classifications included by Mr. Joerg, those of Hult, de Martonne, and Köppen seem to the writer too detailed for general use. Supan's map is the most widely known.³ * * *

The great variety of suggested subdivisions [of the United States], whether primarily physiographic, botanical, zoological, climatic, or "natural regions," is confusing if not discouraging. Moreover, there is no limit to the possible number of classifications, for these depend on any author's special interest or viewpoint, which may be climatic, or botanical, or physiographic, or one of administrative convenience. Even from the single viewpoint of climate alone, an almost infinite number of classifications might be proposed, for we may take as the basis of subdivision either the special conditions of one climatic element, or various combinations of two or more elements.

In working out a scheme of climatic subdivisions there seem to the writer to be a few essential considerations which should be kept in view. The classification must be simple. The separate divisions should, when possible, be bounded by large and easily recognized physical or political lines. Arbitrary limits, difficult to remember and to locate, should be avoided whenever possible. The scheme ought not to be too individual, but should commend itself to those who wish to use it on the ground of its being rational and practical. In any climate in which the cyclonic and anticyclonic control of weather types is a distinguishing characteristic, as it is in the belt of the prevailing westerlies, the climatic subdivisions should be determined with due regard to this control, for it is weather which, in the long run, gives a climate its character.⁴ In other words the subdivisions should be chosen because of their special relations to cyclonic and anticyclonic tracks and movement; to local and characteristic weather distribution around lows and highs; to cyclonic and anticyclonic winds; and because of the general similarity of weather types over each province. Finally, the districts should, as far as possible, be the same as those which have been officially adopted in the publication of the meteorological and climatic data of the

region. If, for example, the published data are grouped according to one scheme while the climatic subdivisions are based upon a different scheme, there is a great inconvenience in the use of these data. To take the specific case of the United States: There is no good and sufficient reason for using other boundaries, State lines, and the divisions adopted in the Weather Bureau's 106 "Climatological sections," are both convenient and practical.⁵ Such a classification of climatic provinces makes it an easy matter to look up the special and detailed characteristics of each subdivision in the official publications of the Weather Bureau. The importance of this point will readily be appreciated by those who have endeavored to work out the climatology of some "climatic province" which did not coincide with any unit area adopted for purposes of publication of the official data.

In the United States there are three great natural topographic and climatic subdivisions. These are (1) the eastern, embracing about one-half of the whole area, extending east from the Rocky Mountains to the Atlantic and Gulf of Mexico; (2) the western mountain and plateau district; and (3) the narrow Pacific slope. Nowhere in the United States are sudden changes in climate to be met with in going from north to south, or vice versa. The transition is everywhere slow and gradual. The natural climatic subdivisions are, therefore, separated by meridional, not by latitudinal, lines. So far as east-west boundaries are necessary, these are therefore inevitably largely arbitrary.

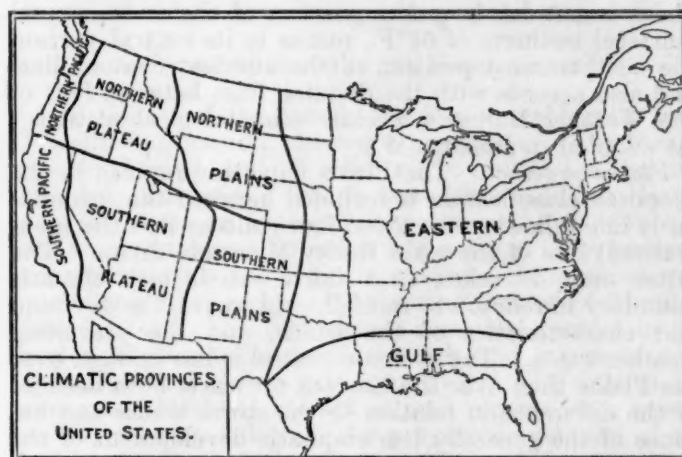


Fig. 1.—Climatic provinces of the United States. (R. DeC. Ward, 1915.)

Eastern province.—The first great eastern climatic district, enormous as is its extent, has nevertheless a certain remarkable uniformity in its weather types and its climate. It is freely open to the east, north, and south; to the Atlantic, to Canada, and to the Gulf of Mexico. Its seasons are strongly contrasted; its winter temperature gradients between north and south are unusually steep; its continental climate reaches to the Atlantic seacoast, with little modifying effect of the ocean waters; its rainfall is, as a whole, plentiful and well distributed throughout the year; its frequent and well-developed cyclones give it many rapid and marked weather changes and sharply contrasted types, controlled to a large extent by the diversity of temperature and of moisture conditions of the district from which the winds come. With the approach toward the Rocky Mountain

¹ Condensed from the Bull. of Am. Geog. Soc., September, 1915, 47: 672-680.

² W. L. G. Joerg. The Subdivision of North America into natural regions. Annals, Assoc. Amer. geogr., 1914, 4: 55-83.

Also gives reference to other classifications not especially considered in the article. It adds greatly to the convenience of the reader that one scale of map is used for all the North American classifications, and one scale for all those dealing with the United States.

³ The classifications of Hult, Köppen, and Supan have been considered by R. DeC. Ward, The Classification of Climates, Bull., Amer. geogr. soc., 1906, 38: 401-412, 465-477. The maps of Supan and Köppen are also reproduced in the writer's Climate, considered especially in Relation to Man, 1908, Chap. III. Supan's map may also be found in Bartholomew's Atlas of Meteorology, 1899, pl. 1.

⁴ This matter has been fully discussed by the writer in a recent paper "The weather elements in American climates," Annals, Assoc. Amer. geogr., 1914, 4: 3-54.

⁵ In Prof. A. J. Henry's "Climatology of the United States" (Weather Bureau Bull. Q, 1906), the numerical data are all given by States.

area, on the west, there comes also a gradual transition to the drier, sunnier, and less cyclonically controlled climate of the Great Plains and eastern foothills. There is here no easily fixed and sharply determinable climatic boundary, although the lines of equal rainfall, cloudiness, and relative humidity all trend very generally north and south. The 100th meridian, the critical mean annual isohyetal line of 20 inches, and the 2,000-foot contour line, are all reasonably satisfactory. For our purpose we have selected the (generalized) line which follows the 2,000-foot contour. This agrees fairly closely with the 20-inch isohyetal line, and also with the 100th meridian, and marks the eastern margin of the physiographic unit of the Great Plains (fig. 1).

Gulf province.—To the south, over the States bordering on the Gulf of Mexico, the temperatures are higher; the winters are much milder; the cyclonic control is weaker; the temperature and weather changes are fewer and less emphatic; diurnal phenomena are more marked; conditions are more "settled"; the rainfall is heavier and usually has a marked summer maximum. Here, on these great warm, damp lowlands of the southern coastal plain we have the wealth of southern cotton and sugar cane and subtropical fruits. For these and other reasons this southern portion of our great eastern district may well be set apart as a subordinate climatic province. There is, however, no sharp climatic boundary of any kind which may be taken as the limit of this southern Gulf province. Hence an arbitrary line has been drawn, which includes on the south most of the Gulf coastal plain; is not far from the position of the mean annual (surface) isotherm of 65°F., marks in its central portion the northernmost position of the 100-foot contour line, and also accords with the dividing lines between four of the Weather Bureau's official "climatological sections" [as adopted in Bulletin W.].

Plains province.—The Plains climatic province in the proposed classification is included between the (generalized) line following the 2,000-foot contour and the (generalized) line of the main Rocky Mountain divide. The latter may be taken as a fairly satisfactory climatic boundary in relation to rainfall, cold waves, the direction and characteristics of the winds, and the prevailing weather types. The cyclonic control is less marked over the Plains than over the Eastern province, both because of the difference in relation to the storm tracks and because of the generally less emphatic development of the storms themselves. The climatic difference due to latitude and relation to cyclonic control are so considerable between the northern and southern Plains that a dividing line, which however marks no climatic boundary, may be drawn following in a general way the State lines between Wyoming, Nebraska, Colorado, and Kansas; and thus

conveniently agrees with the subdivision adopted by the Weather Bureau.

Plateau province.—The Rocky Mountain divide on the east and the Sierra Nevada-Cascade divide on the west (both broadly generalized) are natural and convenient boundaries for the Plateau province. A great interior region of mountain ranges, high plateaus, and deserts, its chief characteristic is its small rainfall. It has the minimum cloudiness and the minimum relative humidity in the United States. Comparatively few cyclonic storms cross it. A persistence of winter high- and of summer low-pressure conditions characterizes it. The rain-shadow effect of its western mountain barrier necessitates irrigation undertakings, and where these are impracticable the aridity of the desert reigns supreme. Severe cold waves of the eastern type are barred out by the Rocky Mountain barrier. Diurnal, rather than cyclonic, phenomena prevail. Mountain climates, with their special peculiarities of strong sunshine, dry air, and large temperature ranges, are here found. An east-west line, roughly coinciding with the State boundaries of Oregon and Idaho on the north, and Nevada, Utah, and Colorado on the south, agrees in a general way with the southern boundary of the Columbia plateau, and also with boundaries of the Weather Bureau climatological sections. Hence, such a line may serve as a convenient division between the northern and southern Plateau provinces.

Pacific province.—The narrow coastal strip west of the Sierra Nevada-Cascades is the Pacific province with its great variety of climates, from rainy to arid, from those of the lowlands to those of the snow-covered mountain tops, from the cool summers of the coast to the great heat of the interior; with its prevailing mildness and equability, its subtropical rainy season and subtropical cyclonic controls, its great forests and its fertile agricultural valleys, its irrigated fruit orchards and its far-famed California health resorts. Between the rainier, cloudier, damper, and more changeable north, and drier and more settled south, the State line between California and Oregon is an easily determined and fairly satisfactory boundary. It does not differ greatly from the topographic divide between these States, and accords with the established scheme of subdivision adopted in the publication of the Weather Bureau climatic data.

For purposes of teaching the writer has found the scheme of climatic subdivisions here presented simple, useful, and satisfactory. The eight separate provinces are large enough to make possible further subdivisions to meet any special preferences or needs. The boundary lines are easily determined and easily remembered. And the provinces here adopted are such that the official Weather Bureau data, which are mostly subdivided on a State basis, may be easily fitted into the scheme.

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR SEPTEMBER, 1915.

EDWARD H. BOWIE, District Forecaster.

[Dated: Washington, D. C., Nov. 2, 1915.]

FROST WARNINGS.

A high area that entered the United States from British Columbia moved southeastward to the Ohio Valley and thence northeastward off the New England coast, and in connection with this high pressure area, warnings of frost were issued on September 21, 22, and 23 for portions of the Lake Region, the Ohio Valley, the North Atlantic States, and the northern portion of the Middle Atlantic States, and frosts occurred substantially as indicated in the warnings, although they failed of verification in the southern Ohio Valley and along the north coast of the Middle Atlantic States.

A high pressure area passed from Saskatchewan to Ontario from the 25th to the 30th, frost warnings being issued on the 26th, 27th, 28th, and 29th for the Lake Region, the northern Ohio Valley, New England, and the northern portion of the Middle Atlantic States. These warnings were justified in almost all cases.

STORM WARNINGS.

In connection with the storm that prevailed in the vicinity of the Bermudas from the 2d to the 8th, inclusive, warnings and advices were disseminated to Middle and North Atlantic ports during the 2d and the 3d, and high winds occurred along the Middle Atlantic coast where storm warnings were displayed. As far as indicated by reports, winds approximating gale force occurred off the coast.

For warnings in connection with the storm that crossed the Gulf coast near Apalachicola, Fla., on the morning of the 4th, see other portions of the text.

In connection with a storm that first appeared over Colorado on the evening of the 9th and passed rapidly northeastward, small craft warnings were ordered on the morning of the 10th for Lakes Michigan, Erie, and Huron, and during the afternoon they were supplemented by advisory warnings covering eastern Superior, northern Michigan, and northern Huron. Winds of gale force occurred over southern Michigan and western Erie, and strong winds elsewhere over the Lakes.

A storm passed north-northeastward from eastern Colorado on the 13th to Ontario by the 15th, and small craft warnings were issued on the 14th for portions of the Upper Lakes, and fresh to strong winds occurred.

From the 16th to the 18th there were indications of a disturbance of minor character near the extreme western end of Cuba and in the central Gulf, and shipping interests were advised accordingly. The storm, however, did not advance northward.

A storm advanced from southern Alberta on the evening of the 18th to the Grand Banks by the 23d. On the evening of the 19th storm warnings were ordered for western Superior, and on the following morning storm warnings were ordered displayed over the remaining portions of the Upper Lakes, except extreme southwestern

Lake Michigan, and advisory messages sent to ports on Lake Erie. On the morning of the 21st small craft warnings were issued for the New England coast, and during the afternoon storm warnings were ordered from Sandy Hook to Portland.

Warnings regarding the New Orleans hurricane appear in another portion of the text. Warnings were issued daily from the 22d to 30th, inclusive, in connection with this hurricane.

A storm developed over the Plains States, and on the morning of the 25th it was central over western Minnesota, whence it moved rapidly eastward to the Grand Banks by the 28th. On the evening of the 25th storm warnings were ordered for Lake Superior and northern Lake Michigan, and on the 26th for the Lower Lakes and southern Huron, and also for the Atlantic coast from Cape Henry to Eastport. Gales occurred over the Lake Region generally and along the middle and north Atlantic seaboard.

On the evening of the 26th warnings were continued on Lakes Michigan and Superior, at which time a storm was over Kansas and a marked high area over western Ontario. The low decreased in intensity and storm winds did not materialize. The warnings were accordingly ordered down on the morning of the 27th.

STORM OF SEPTEMBER 1-9 IN THE REGION OF BERMUDA.

On the 1st of the month the 8 a. m. cablegram from Hamilton, Bermuda, showed a pressure of 29.91 inches, the wind north and 26 miles an hour, and the weather cloudy. During the 1st, pressure fell steadily at Hamilton, and at 8 a. m. of the 2d the pressure was 29.46 inches, the wind northwest, 36 miles, and raining. The pressure continued to fall, and at 8 p. m. of the 2d, the barometer reported was 29.18 inches with the wind northwest, 24 miles, and raining. This disturbance remained central in the region of Bermudas until the 8th and much of this time the wind blew a gale from nearly all points of the compass. Without the aid of mail reports from vessels on the western Atlantic, the geographic position of the origin of this disturbance can not be definitely determined, but there is some evidence that it was present during the last days of August to the east-northeastward of the Lesser Antilles, whence it, in all probability, moved northwestward to the vicinity of Bermuda, and there meeting with high pressure in its path was held practically stationary for several days. It is also probable that this is the same storm that was encountered by one of the Royal Mail steam packets during the latter part of August in latitude 22° N. and longitude 47° W. On the 1st storm warnings were displayed on the North Carolina coast northward to Cape May and on the 2d the region covered by the warnings was extended northward to Cape Cod. The advices were to the effect that northerly gales would be encountered off the middle Atlantic and southern New England coasts. The warnings were justified. The highest winds were off the Virginia Capes, Cape Henry reporting a maximum velocity of 48 miles from the northeast at 8 p. m. of the 2d. Advices concerning this storm were disseminated daily

through the naval wireless. On the 9th the storm recurved west and north of Bermuda.

An interesting report of this was received from Capt. D. W. Wilson of the steamship *Kilbride*. The *Kilbride* was at anchor during the period covered by the report in Great Sound, about 3 miles off Gibbs Hill Lighthouse. By comparison with reports from the regular station at Hamilton, it seems that the barometer on board the *Kilbride* reads about 0.20 inch high. No corrections have been made. This report follows:

September 1: It blew fresh all day from the north; 3 p. m., barometer 29.65 inches and thermometer 80°; 9 p. m., wind backed to northwest, barometer 29.30 inches, thermometer 78°; an ugly, threatening appearance of the sky; 11 p. m., let go starboard anchor and paid out on both cables to 75 fathoms on port and 30 fathoms on starboard; very violent rain squalls all night.

September 2: 8 a. m., barometer 29.30 inches, thermometer 78°, wind still blowing hard from northwest; 1 p. m., barometer 29.18 inches, thermometer 81°; 4 p. m., barometer 29.03 inches, thermometer 81°, wind backed to west; strong wind and increasing in force; sky densely overcast, with drizzling rain at intervals.

September 3: 6 a. m., barometer 28.90 inches, thermometer 81°, wind backed to southwest, increasing in force all the time; noon, barometer 28.90 inches, thermometer 81°, gale rapidly increasing in violence with terrific squalls, dangerous confused sea running; 4 p. m., barometer 28.85 inches, wind backed to south, now blowing hurricane force; 8 p. m., barometer 29.05 inches, thermometer 81°, wind backed to southeast, blowing a hurricane with heavy sea, thick and misty, and unable to see any distance; 10 p. m., barometer 29.05 inches, thermometer 82°, still blowing hurricane force with heavy rain, sky densely overcast with very thick atmosphere; 11 p. m., barometer 29.05 inches, thermometer 82°; midnight, barometer and weather the same, using main engines, steaming head to wind and sea and using helm as required to prevent sheering and to relieve strain on cables. Heavy, short, and dangerous sea.

September 4: 1 a. m., barometer 29.05 inches, thermometer 83°, no change in weather; 4 a. m., barometer 29.05 inches, thermometer 82°, wind backed to east-southeast; 8 a. m., barometer 29.06 inches, thermometer 79°, wind backed to east; 11 a. m., barometer 29.10 inches, thermometer 78°, wind backed to east-northeast; noon, barometer 29.11 inches, thermometer 78°, tremendous hurricane, with blinding, heavy rain and densely overcast sky, unable to see any distance; 4 p. m., barometer 29.16 inches, thermometer 76°, wind the same (east-northeast), but less rain; 8 p. m., barometer 29.20 inches, thermometer 77°, hurricane abating a little, weather clear at times; sky overcast, much less sea.

September 5: 4 a. m., barometer 29.33 inches, thermometer 82°, wind the same (east-northeast), but much finer weather; 8 a. m., barometer 29.35 inches, thermometer 82°, wind decreasing, weather inclined to be squally, with heavy rain; noon, barometer 29.40 inches, thermometer 81°, wind backed to northeast, fresh breeze and overcast sky, with a promising appearance of the weather becoming settled; stopped engines; 4 p. m., barometer 29.40 inches, thermometer 82°, strong breeze and overcast sky; 10 p. m., barometer 29.45 inches, thermometer 79°, wind veered to east-northeast, weather improving.

September 6: Noon, barometer 29.50 inches, thermometer 78°, wind east-northeast, freshening and sea rising, heavy rain squalls.

September 7: 6 a. m., barometer 29.47 inches, thermometer 77°, gale, wind veered to east, using main engines and helm again as required; 4 p. m., barometer 29.30 inches, thermometer 75°, whole gale, wind veered to east by south, densely overcast, with continuous misty rain, unable to see any distance; 6 p. m., gale abating, sea falling; 10 p. m., barometer 29.25 inches, thermometer 81°, wind decreasing and veered to southeast, weather improving.

September 8: 2 a. m., great improvement in the weather, barometer 29.25 inches, thermometer 82°, wind veered to south-southeast, rough sea; 2 p. m., barometer 29.26 inches, thermometer 80°, fresh breeze, wind veered to south, weather misty, with drizzling rain; 5 p. m., barometer 29.25 inches, thermometer 77°, wind gradually veered to southwest, fresh breeze all night, with misty rain at times.

September 9: 8 a. m., barometer 29.57 inches, thermometer 78°, wind still southwest, moderate breeze, clear and improving weather; noon, barometer 29.62 inches, thermometer 80°, wind still southwest, weather improving all the time.

TROPICAL STORMS DURING SEPTEMBER.

Between the northeast trade winds of the North Atlantic and the southeast trades of the South Atlantic Ocean there lies a belt of relatively low pressure, light variable winds, calms, and vapor-laden air, commonly referred to as the "doldrums." This belt of calms separates the

general wind circulation of the Northern from that of the Southern Hemisphere, and it shifts northward and southward with the sun, but lags so that the sun reaches its maximum north declination in June, while the "meteorological equator" is farthest north in August. This belt is the birthplace of tropical cyclones or hurricanes, but it is only when this belt lies farthest north that the right-hand deflecting force of the earth's rotation becomes so effective that it gives the air moving toward some local area where the air has become superheated, a gyratory motion. Hence hurricanes are most frequent during the month of August and September. Why they should be more frequent in some years than in others is not yet understood.

Figure 4 (XLIII-113) shows for the West Indian and Gulf of Mexico waters the probable 24-hour movements of cyclones in the month of September. To illustrate: If the center of a cyclone is located in the vicinity of the end of one of the arrow shafts, then 24 hours later its center will be near the head of this arrow. The movements are the averages of all cyclones observed in September in the years 1873 to 1910, inclusive.

Tropical storm of September 2-7.

When a powerful storm is in the region of Bermuda it is uncommon to have a storm of other than minor intensity in southern waters adjacent to the United States. However, a storm of small diameter, but of great intensity, made its appearance near Isle of Pines the afternoon of the 2d and moved thence on a northerly course and crossed the coast line near the mouth of the Apalachicola River during the early morning hours of the 4th, losing its intensity immediately thereafter, but retaining its identity until it reached the region of the Great Lakes. In the forenoon of the 2d the following special advice was received from the official in charge at Key West, Fla.:

Clouds give evidence (of) perfect cyclonic organization central nearly south.

Special observations at 4 p. m., from Habana, were immediately called for and these showed a storm in the vicinity of the Isle of Pines. Storm warnings were immediately ordered displayed on the south Florida coast, and the following advisory message was distributed:

Northeast storm warnings displayed south Florida coast. Tropical disturbance at 4 p. m. to-day, central near Isle of Pines and moving toward the northwest. It will be dangerous for shipping in southern Florida and east Gulf waters during the next two days.

During the morning of the 3d several special observations were received from the steamship *Turrialba*, as follows:

Observations on the Turrialba September 3, 1915.

Hour of observation.	Latitude.	Longitude.	Barometer.	Temperature.	Wind direction.	Force.	Weather.
	" "	" "	Inches.	" F.			
2 a. m.	24 20	84 02	29.62	80	ne.	9	Raining.
4 a. m.	24 18	84 00	29.08	80	sw.	6	Raining.
7 a. m.	24 10	83 50	29.56	82	sw.	8	Cloudy.
8 a. m.	24 00	83 40	29.70	82	s.	7	Cloudy.

These reports, together with that of the *Miami* which follows, enabled the forecaster at Washington to locate quite accurately the center of the disturbance. The following report was received from the U. S. Coast Guard Cutter *Miami* by radio:

Approximate position, latitude 24° 46', longitude 83° 50'. Storm center passed to east of our position about 7 a. m., wind north 80 to 100 miles, barometer 29.38. Wind shifted to west 8 a. m., and moderating.

Hurricane warnings were accordingly issued for the western coast of Florida and thence westward to the mouth of the Mississippi River. In these warnings it was predicted that the storm center would strike the coast between Cedar Keys, Fla., and New Orleans, La. Actually it crossed the coast line about midway between these points. These warnings were as follows:

(Issued Sept. 3, 9:10 a. m.)

Hoist hurricane warnings 10 a. m. New Orleans to Cedar Keys and southeast storm warnings at Tampa. Tropical storm central this morning in Gulf in latitude 25° and longitude 85°, approximately, and moving northwest toward middle Gulf coast. It will probably strike Gulf coast between New Orleans and Cedar Keys, and hurricane warnings are ordered accordingly. Advise all interests.

(Issued Sept. 3, 11:08 a. m.)

Change to southeast storm warnings Boca Grande to Jupiter. Fresh southeast and south gales on the southwest Florida coast and strong southeast winds on southeast Florida coast. Storm apparently moving north-northwestward.

(Issued Sept. 3, 11:52 a. m.)

Hoist hurricane warnings Rockwell to Puntarasa. Storm moving north in about latitude 26°, longitude 84° to 85°. Winds of hurricane force off the coast this afternoon and to-night.

(Issued Sept. 4, 9:20 a. m.)

Advisory storm warning. Center of tropical storm apparently approaching Gulf coast near the mouth of Apalachicola River. Will pass inland late this afternoon or to-night and then diminish in intensity. Hurricane warnings limited to region between Panama City and Cedar Keys, Fla.

After crossing the coast line this disturbance decreased in intensity as it passed northward to Lake Huron and lost its identity by the evening of the 7th.

This storm apparently originated south of Cuba and passed northward near Isle of Pines. A report from the Cuban Meteorological Service states that the barometer at Pinar del Rio on the 2d at 7:30 p. m. was 29.74 inches, wind northeast, 20 miles; and at 10:30 p. m., the barometer was 29.70, wind northwest, 26 miles. The wind having backed from northeast to north-northwest, it may be inferred that the center of the hurricane passed to the east of the city. Comparing these observations with those at Habana, where the minimum pressure, 29.66 inches, was observed at 11:45 p. m. of the 2d, with a maximum wind velocity of 50 miles from the southeast at the same hour, it follows that the center of the disturbance passed in the vicinity of San Cristobal, in Pinar del Rio, and passed to the Gulf near La Mulata. The minimum barometer at the Isle of Pines was 29.52 inches at 5 p. m., to which it had fallen from 29.72 at noon.

Key West report.—No casualties or damage at or in the vicinity of this station. Lowest barometer 29.76 inches about 3 a. m. of the 3d.

Tampa report.—In this vicinity very high tides were reported, some the highest of record. At St. Petersburg, Fla., the tide exceeded by 4 feet 10 inches, the previous high record. Damage from wind and tide is confined to that portion of the coast north of Manatee. The greatest damage was done to the sponge fleet. At Passa Grille the sea wall was considerably damaged by the extremely high seas. An aneroid barometer (recently compared) at Passa Grille showed a reading of 29.60 inches, 0.18 inch lower than at Tampa. The official in charge at Tampa remarks: "This means a gradient of 0.18 inch in 25 miles. The tide was the highest of record at Manatee. At Clearwater there was not much wind, but the highest tides in years."

Every available means was employed to disseminate the warnings—rockets, flags, telephone, telegraph, launches, etc. The storm moved so rapidly that the Weather Bureau warnings were issued hardly 24 hours in

advance. They undoubtedly saved many lives and much property.

Jacksonville report.—The tide was unusually high at all Gulf stations, unprecedented some reports indicate. The loss of life was confined to fishing and sponge vessels at sea which had no knowledge concerning the approach of the storm. The apprehension awakened by the recent hurricane that traversed the Gulf coast striking the coast line of Texas near Galveston, was still much alive and to the fear thus provoked, together with the usual accuracy of warnings, must be attributed the small loss of life and property during the storm of September 3-4. Warnings were heeded by large and small vessels, possibly as never before, all realizing that indifference might exact the penalty of great disaster. Thus again is exemplified the value of the bureau to the marine and industrial interests of the country. At Apalachicola the wind was highest, 60 to 70 miles an hour, from the east-southeast between 4 and 7 a. m. of the 4th, veering to southwest. The loss of timber on turpentine farms will be about 10 to 15 per cent or more. The damage to buildings, small boats, and other exposed property, including telegraph and telephone wires will approximate \$25,000. The tide was highest about 5 a. m., having risen 4 feet above normal within about an hour. No lives were lost in the city, owing to the timely precautions taken by all interests. Small vessels sought harbor, although many small boats and one tug were sunk. From 4 a. m. to 7 a. m. the wind blew from 50 to 60 miles an hour, and for 30 or 40 minutes it was 70 miles. The warnings on the 2d and 3d gave every one ample time to put boats, barges, and all floating property in harbor. The lowest barometer reading was 29.32 inches at 6:40 a. m. At Carrabelle the tide was 7 feet above normal. No lives were lost, but fences, telephone poles and smokestacks were blown down, piers were washed away, several barges and small boats were blown ashore into the marshes and left high and dry after the storm. The highest wind velocity of 60 to 70 miles an hour (estimated) occurred about 6 a. m. from the southeast. The lowest barometer was 29.45 inches at 5:30 a. m. of the 4th. Warnings were received in ample time and highly valued. All interests were prompt in taking protective measures. At Cedar Keys the highest wind velocity, about 40 miles an hour, occurred during the night of the 3d-4th from the southeast. The tide was very high. No lives lost and damage to property small, as warnings were received in time and preparations for safety taken by all. At Panama City the wind was very high and backed from northwest to southwest. The highest velocity occurred at about 7 a. m. Some roofs were blown off and several fishing vessels went ashore. The warnings were received in time, and all shipping and the public were warned to make everything safe. Small boats went into the harbor and the larger ones used every precaution. Everybody appreciated the Weather Bureau advice.

Pensacola report.—The tide was not unusually high. The highest wind velocity was 33 miles an hour from the north at 11:08 a. m. of the 4th. The lowest pressure was 29.80 inches at 10 a. m. of the 4th. There was no damage. At St. Andrews the lowest barometer reading of 29.40 inches occurred at 7:45 a. m. On the morning of the 4th the wind had backed to north, and by 5 a. m. began to increase in velocity and was coming in gusts of 50 to 60 miles an hour. A little before 7 a. m. the wind shifted to northwest and possibly for a moment blew 80 miles an hour. It was then that the most damage was done in the way of uprooting and twisting off of trees.

Tropical storm of September 22-30.

On September 22, in the "doldrums" in about latitude 15° N. and longitude 64° W., the forecaster on duty at the central office at Washington, D. C., detected the first signs of the formation of another hurricane, although he had no reports from that immediate region. This storm began to manifest its presence by the changed wind directions, by the clouds and their peculiar movements that usually occur when a hurricane is somewhere near. Advices on the 22d were sent West Indian stations and shipping bound for West Indian waters. Later reports confirmed the deduction that a storm was in process of formation, and day to day thereafter until the storm passed inland near the mouth of the Mississippi River advices and warnings were issued for the guidance of shipping and the residents of the Gulf coast regions. The track of this hurricane is shown on figure I. M. C. 3 (XLIII-113), which also shows the track of the hurricane that passed near Galveston on August 16, 1915, and the one of lesser importance that passed inland near the mouth of the Apalachicola River on September 4, 1915. It is in fact unparalleled that three hurricanes should reach the Gulf coast within a period of approximately six weeks.

The New Orleans hurricane was equal to and possibly surpassed in intensity the one that occurred at Galveston in August. At New Orleans the lowest pressure, reduced to sea level, standard gravity, etc., was 28.11 inches, which is the lowest reading ever recorded at a Weather Bureau station, and the extreme wind velocity was approximately 130 miles an hour from the east. Figure 5 (XLIII-114) shows the sea-level pressure at New Orleans during the coming and passing of the storm. Figure 1 (XLIII-112) is the weather map of 8 p. m., September 29, or approximately two hours after the center of the storm passed immediately west of New Orleans. The pressure at New Orleans was then rising. The continuous lines on this chart are drawn for each 0.10 inch of pressure, except in the immediate vicinity of the storm center, where the gradient is so very steep that it is not possible to show the lowest closed isobar. The arrows show the direction of the wind at the various stations within the storm area; the number of feathers on the staff of an arrow indicates the force of the wind (Beaufort scale) at the time of the observation.

On the morning of September 28, the following warning was sent Gulf ports, whence it was disseminated by every available means:

Tropical storm attended by dangerous winds central this morning over the Gulf of Mexico in approximately latitude 24° and longitude 87° , moving northward toward the mouth of the Mississippi River. Its influence will be felt late to-night and Wednesday on the middle Gulf coast.

At 3 p. m. of the 28th hurricane warnings were ordered displayed and disseminated on the Gulf coast from New Orleans, La., to Pensacola, Fla. The message read as follows:

Hoist hurricane warnings 3 p. m. New Orleans to Pensacola. Tropical storm center near latitude 26° and longitude 88° and moving northward. Dangerous winds late to-night and Wednesday. The storm center will probably strike the coast near or immediately east of the mouth of the Mississippi River. Advise all interests.

Of especial importance and helpfulness to the forecaster in the preparation of the advices and warnings concerning this storm, which from the time of its formation in the eastern Caribbean Sea to the time it struck the mouth of the Mississippi, did not pass close to a land station, were the wireless reports from vessels at sea.

While no one of these vessels reported from the immediate storm center, yet their reports were invaluable in that they permitted the center to be located approximately twice each day.

The following is a record of the more important advices and warnings issued by the Weather Bureau from the time the hurricane made its first appearance over the eastern Caribbean Sea until it passed inland near the mouth of the Mississippi River:

September 22.—There are some indications of a disturbance over the Caribbean Sea immediately west of the island of Dominica. (This information was transmitted to Porto Rico and the Windward Islands.)

September 23.—Some indications of a disturbance central over the Caribbean Sea in latitude 15° and longitude 67° . (This information was sent to all West Indian stations, to important ports on the Atlantic and Gulf coasts, and distributed by United States Radio Service to vessels at sea.)

September 24.—At 4 p. m. to-day the pressure was low over the Caribbean Sea, and there were indications of a disturbance south-southeast of Kingston, Jamaica, where the wind was east, force 2, and the barometer read 29.74 inches. Strong easterly winds are prevailing on the south coast of Haiti. This disturbance will probably move west-northwest. (This information was given a distribution similar to that given the advices of the 23d instant.)

September 25.—Tropical cyclone central this morning immediately southwest of Jamaica and moving toward the Yucatan Channel. Vessels bound for Yucatan Channel and western Caribbean Sea should exercise every precaution. (This information was distributed to all Atlantic ports, Habana, and the vessels at sea by means of the Naval Radio Service.)

September 26.—Tropical cyclone over the Caribbean Sea central south of western Cuba and apparently moving northwest toward the Yucatan Channel. Vessels sailing for the Yucatan Channel and western Caribbean waters should exercise extreme caution. (This information was distributed in a manner similar to the advices of Sept. 25.)

September 27.—The tropical cyclone over the western Caribbean Sea is central near and southwest of the Isle of Pines, and apparently moving northward. It is dangerous for vessels in western Cuban and southern Florida waters and the Yucatan Channel. (This advice was given widespread dissemination to the South Atlantic and Gulf seaports and vessels at sea by means of Naval Radio Service.)

September 28.—Tropical storm, attended by dangerous winds, over Gulf of Mexico in approximately latitude 24° and longitude 87° and moving northward toward the mouth of the Mississippi River. Its influence will be felt late to-night and Wednesday on the middle Gulf coast. At 10 a. m. storm warnings were displayed on the middle Gulf coast, and at 3 p. m. an order to hoist hurricane warnings was sent to the region between New Orleans and Pensacola. This warning read as follows:

Tropical storm center near latitude 26° and longitude 88° and moving northward. Dangerous winds late to-night and Wednesday. Center of storm will probably strike coast near or immediately east of the mouth of the Mississippi River. Advise all interests.

September 29.—The following information was distributed on the Louisiana coast:

Tropical disturbance moving toward southeast Louisiana. Center will probably pass between New Orleans and Atchafalaya Bay. Easterly gales, probably reaching hurricane force on eastern Louisiana and strong northerly winds to moderate gales on west coast to-day and to-night. High tides.

Also hurricane warnings were continued on the Mississippi, Alabama, and extreme northwest Florida coasts, east to south gales being forecast for the afternoon and night.

A detailed statement concerning the hurricane, September 22-29, at New Orleans appears elsewhere in this Review. (See pp. 456-466.)

DISTRICT WARNINGS DURING SEPTEMBER.

Chicago district.—There were no special warnings issued during the month with the exception of frost or freezing temperature, and the more important warnings for the various sections were as follows:

12th.—Freezing temperature for North Dakota and Montana (verified at the majority of the stations therein).

20th.—Frost for the entire Northwest from the upper Mississippi Valley westward (fully verified).

21st.—Frost for the western Lake region and the upper Mississippi Valley (partly verified).

A warning was issued on the 20th for the Wisconsin tobacco region, as follows:

Frost indicated to-night in tobacco region of western portion of the State. Conditions a little doubtful in southern and central portions, but frost possible. Frost quite likely, however, Tuesday night.

During the month a number of long-range forecasts covering three days to a week were requested by local Exchanges or State Fair Associations in various sections, as follows: On the 11th, Huron, S. Dak., one week; 13th, Madison, Wis., three days; 17th, Springfield, Ill., one week; 18th, Sioux City, Iowa, two days; 19th, Helena, Mont., one week; 25th, Sedalia, Mo., one week; and on the 27th, Peoria, Ill., five days. These forecasts met with exceptional success and were fully verified in practically every case.

Denver district.—Frost warnings were issued for portions of the district on a number of days during the month.

New Orleans district.—No important warnings, except those in connection with the hurricane, which are given elsewhere (pp. 456-466).

San Francisco district.—On the 10th, 23d, 24th, and 25th warnings of probable showers were issued to the fruit-drying interests, and while the reports from regular Weather Bureau stations in this district show rain in only a few instances, scattered light showers occurred in most sections, especially the mountain and foothill districts, and the warnings were justified.

Portland district.—Not received.

NORTHERN HEMISPHERE PRESSURE.

Honolulu.—Pressure averaged near, though slightly below, normal. The principal lows and highs occurring as follows: Lows, 9th-10th, 18th, and 21st-22d; and highs, 25th and 28th-29th.

Alaska.—Pressure averaged slightly below the seasonal average, except at Sitka and Dutch Harbor, where it was slightly above. Lows occurred about the 2d, 6th-7th, 13th-15th, 25th and 29th, and highs about the 4th-5th, 10th, 16th-19th, and 22d-23d. The principal high was that of the 10th, and the principal lows were those of the 25th and 29th.

Azores.—Pressure averaged nearly normal, although slightly below. Fluctuations were not marked. Pressure was below the normal from the 10th to 22d and above thereafter.

Bermuda.—Pressure averaged below normal, being continuously below during the first decade and above during the greater portion of the remainder of the month.

United States.—Lows occurred about the 7th-9th, 13th-14th, 20th, and 26th, and highs about the 2d, 11th, 15th-16th, 17th-18th, 22d, and 24th-25th.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS OF SEPTEMBER, 1915.

By ALFRED J. HENRY, Professor of Meteorology, in Charge of River and Flood Division.

[Dated: Washington, D. C., Oct. 28, 1915.]

Atmospheric conditions favorable to intense precipitation over limited areas in eastern Kansas, northeastern Iowa, northwestern Illinois, south-central Wisconsin, south-central Michigan, and west-central New York, obtained on several dates during the month. In order to show the horizontal distribution of precipitation in the flooded districts reports from many more points than are at present available would be necessary. Moreover, there were practically no river-gaging stations on the great majority of the streams affected and no comparative statistics of the stages reached can be had. The expression "higher than ever before known" is interpreted to mean an unusually high stage. The descriptions of local floods contained in news items in the public prints are overdrawn, but nevertheless they afford practically the only information at hand respecting the floods at points not occupied by the Weather Bureau river service.

In the tables which follow will be found statements, based upon actual gage readings, of the time that each river therein was in flood and also the crest stage of the flood. In the matter which follows, under the caption "Local Floods, etc.," no gage readings are available.

TABLE 1.—Flood stages in the Missouri River and tributaries, September, 1915.

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			Feet.	
Osage.....	Ottawa, Kans.....	20.0	16	26	26.2	9
Osage.....	Osceola, Mo.....	20.0	16	26	28.4	19
Grand.....	Chillicothe, Mo.....	18.0	17	17	18.9	17

TABLE 2.—Flood stages in the Arkansas River and tributaries, September, 1915.

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			Feet.	
North Canadian....	Canton, Okla.....	3.0	20	20	3.8	27
Neosho.....	Le Roy, Kans.....	24.0	8	8	24.5	8
Neosho.....	Iola, Kans.....	10.0	7	8	14.7	7
Neosho.....	Oswego, Kans.....	20.0	13	13	22.6	21
Neosho.....	Fort Gibson, Okla.....	22.0	19	20	22.5	19
Black.....	Black Rock, Ark.....	14.0	1	14	24.9	1
White.....	Newport, Ark.....	26.0	1	1	26.0	1
White.....	Georgetown, Ark.....	22.0	1	8	24.3	1
White.....	Clarendon, Ark.....	30.0	1	10	33.0	2 & 3

TABLE 3.—Flood stages in the rivers of Texas, September, 1915.

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			Feet.	
Sabine.....	Orange, Tex.....	4.0	1	6	4.9	1
Neches.....	Beaumont, Tex.....	7.0	1	2	8.2	1
Colorado.....	Austin, Tex.....	18.0	17	17	24.7	17
Colorado.....	Columbus, Tex.....	24.0	19	21	32.5	20
Guadalupe.....	Victoria, Tex.....	16.0	23	23	17.0	23

TABLE 4.—Flood stages at other points, September, 1915.

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			Feet.	
Mississippi.....	Arkansas City, Ark.....	42.0	1	7	43.6	3
Des Moines.....	Ottumwa, Iowa.....	10.0	28	30	11.4	28
Grand.....	East Lansing, Mich.....	7.5	14	15	7.7	15
Walhonding.....	Walhonding, Ohio.....	8.0	6	6	9.7	6
Illinois.....	La Salle, Ill.....	18.0	1	2	18.3	1
Illinois.....	Beardstown, Ill.....	12.0	22	30	14.7	1

These tables, in connection with the text which follows, presents a summary of our knowledge with respect to the flood conditions during the month.

Floods in the Neosho River.—The following is abstracted from a report by Observer H. H. Holcomb, in charge of the district center at Iola, Kans.:

Excessive rains fell in southeastern Kansas on September 6 and 7, the region of greatest intensity being in Allen and Bourbon Counties, where the 24-hour fall was 6.80 inches at Iola; 10.33 inches at Moran, in Allen County, and 6.10 inches at Fort Scott, in Bourbon County. During the night of September 6-7, over Elm, Elsmore, and Marmaton Townships, in Allen County, the precipitation was in excess of 10 inches and caused the tributaries of the Neosho River, which enter the main stream in the vicinity of Iola, Kans., known as Deer Creek, Elm Creek, Coon Creek, and Big Creek, to become torrents ranging from 1 to 3 miles in width. The lowlands along these tributaries became flooded during the night and along the streets in the flooded district of Iola over 600 families were rescued by boats and rafts, in many instances after the water had reached the second story of the houses. Several hundred families were also reported to have been rescued under similar conditions at Humboldt and Fort Scott.

The Neosho River at Iola rose 14.1 feet within 12 hours and stood 4.7 feet above flood stage, which was the highest stage recorded since July 10, 1904, and within one-half foot of the stage then attained. While the damage from flooded conditions was greatest in Allen, Neosho, and Labette Counties, the river rose above flood stages along the course from Iola south to the Kansas-Oklahoma State line, a distance of 129 miles by the river channel, or 68 miles in a straight line. In this part of the river the average fall is only about 1.2 feet per mile, which, together with the meandering course and congestion by driftwood, caused a very extensive area to be flooded. Warnings were sent to Chanute, Erie, Oswego, and Chetopa, Kans., in time for the protection and removal of endangered property to places of safety.

Before this flooded condition had quite subsided excessive rains again occurred on the 14th and 15th, with 5.09 inches at Iola, nearly 5 inches on the two dates occurred at other river stations in the dis-

tract. Following the heavy rains, the reservoir for impounding the city water supply at Yates Center on Owl Creek, a tributary of the Neosho River, was broken and augmented the flooded conditions. Along the river course from Iola south to the Kansas-Oklahoma line flooded conditions were again attained. At Oswego and Chetopa the river stages exceeded the former flood of this month, and the river continued above flood stage from September 17 to 22, inclusive. The crest occurred at Oswego September 21, with a stage of 22.6 feet. Warnings were sent to points along the river in ample time for removal of property.

The greater losses were unpreventable and included bridges, crops, levees and live stock, although extensive damage was sustained by the cement mills, railroads and smelters in the flooded district. In Allen County alone five bridges were damaged until repair work became very expensive, or impossible, and new bridges must be constructed. Losses to individuals included household furniture, buildings, live stock, and in addition a complete loss of crops on the overflowed lands. The greatest damage to the railways was sustained by the Missouri Pacific, the Santa Fe, and the Missouri, Kansas & Texas Railway companies. Three thousand feet of track of the Missouri Pacific Railway was washed out. The tracks of the other companies were submerged in several localities and trains prevented from running several days. The damage to the Iola Electric Street Railway was estimated by the superintendent at \$8,000. The loss to the Iola Portland Cement Plant not only included the enforced shutting down of the mill for several weeks, where over 300 men were employed, but the removal of water 30 feet in depth from a quarry of 55 acres extent, the water pumped out of the quarry estimated at 500,000,000 gallons, before work could be resumed, and the loss totaled \$25,000.

Losses due to September, 1915, floods in Neosho River.

Buildings, factories, municipal plants, highways, bridges...	\$900,000
Crops, which may or may not have been housed.....	500,000
Prospective crops, 96,000 acres involved.....	960,000
Live stock or other movable property.....	50,000
Suspension of business, including wages of employees.....	50,000
Total.....	2,460,000

Local floods in Iowa, Illinois, Wisconsin, and New York.—Heavy local rains occurred on the 10th in lower Michigan, the rain at Grand Rapids being in the nature of a cloudburst. Sewers were inadequate to carry it off and as a consequence much damage was done by the flooding of basements.

On the 11th heavy local rains in northwestern Illinois flooded low places and caused streams to overflow. On the following day the region of heavy local rains was centered over the counties of Rock, Greene, Dane, and Lafayette, Wis. The damage to highways and bridges was unusually great. Washouts on the railroad between Janesville and Edgerton and between Edgerton and Madison caused delay in traffic and the derailment of two trains. Five lives were reported as being lost due to the floods.

The money loss in the State of Wisconsin, as reported in the press, amounted to \$1,400,000.

The same disturbance, as it moved eastward, was the cause of much loss of property in central New York during the night of the 12th, especially along Erie Canal in the vicinity of Syracuse. Newspaper reports estimate the damage to mills, factories, railroads, and dwelling houses at Skaneateles and Skaneateles Junction as amounting to \$75,000.

Northeastern Iowa, northwestern Illinois, and southwestern Wisconsin were visited by a second series of torrential rains on the 25th and 26th. According to Local Forecaster J. H. Spencer, of Dubuque, Iowa, the area of heavy rainfall extended from Blackhawk County, Iowa, to Jo Daviess County, Ill., and Grant County, Wis. All of the small streams in this region had overflowed their banks by the morning of the 27th, causing much damage to the highways, bridges, culverts, railroad beds, and crops.

The greatest damage to crops was in the bottom lands along the Galena and Maquoketa Rivers, Catfish Creek, and other smaller streams.

Following is a conservative estimate of the property loss:

Railroads.....	\$20,000
County roads and bridges.....	25,000
City of Dubuque, Iowa (roads).....	5,000
Private property.....	10,000
Crop loss.....	20,000
Total.....	80,000

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

MEAN LAKE LEVELS DURING SEPTEMBER, 1915.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Oct. 4, 1915.]

The following data are reported in the Notice to Miners of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during September, 1915:				
Above mean sea level at New York.....	Feet. 602.49	Feet. 579.96	Feet. 572.20	Feet. 245.45
Above or below—				
Mean stage of August, 1915.....	+0.08	—0.15	—0.12	+0.02
Mean stage of September, 1914.....	—0.32	—0.51	—0.12	—0.64
Average stage for September, last 10 years.....	—0.21	—0.85	—0.19	—0.78
Highest recorded September stage...	—1.59	—3.47	—1.74	—2.16
Lowest recorded September stage....	+1.00	+0.30	+0.92	+1.45
Probable change during October, 1915.....	—0.1	—0.2	—0.3	—0.4
Average relation of the September level to:				
August level.....	+0.1	—0.2	—0.3	—0.4
October level.....	0.0	+0.2	+0.3	+0.4

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR SEPTEMBER, 1915.

WILLIAM J. HUMPHREYS, Professor in charge of Seismological Investigations.

[Dated: U. S. Weather Bureau, Washington, D. C., Oct. 30, 1915.]

TABLE 1.—Noninstrumental earthquake reports, September, 1915.

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
CALIFORNIA.										
6	H. m.	Mesa Grande.....	33 11	116 42	4	1	M. s. 1	Loud.....		Edward H. Davis.
8	2 20	Point Loma.....	32 43	117 15	5	1		Rumbling.....	Swayed buildings.....	F. J. Dick.
8	7 42	San Diego.....	32 43	117 10	2	1				U. S. Weather Bureau.
8	12 45	Coalinga.....	35 19	120 20	4	2	8			L. Nuckolls.
12	45	Paso Robles.....	35 34	120 40	4	1	4			F. W. Sawyer.
12	45	San Luis Obispo.....	35 18	120 39	2-3	2	20			U. S. Weather Bureau.
20	13 00	Yorba Linda.....	33 51	117 50	3	1				W. A. Walker.
NEBRASKA.										
16	19 00	Kirkwood.....	42 45	99 17	3	1	30	Loud.....	Explosion(?).....	Mrs. C. Arter.
NEVADA.										
2	22 42	Gerlach.....	40 38	119 24	3	1				W. T. Dauterman.
3	0 50	Gerlach.....	40 38	119 24	4	1	1 00		Swayed buildings.....	W. T. Dauterman.
3	5 57	Gerlach.....	40 38	119 24	6	1	3 00		Cracked concrete floor.....	W. T. Dauterman.
3	9 10	Gerlach.....	40 38	119 24	3	1	4			W. T. Dauterman.
UTAH.										
20	1 28	Thistle.....	40 00	111 36	3	2	6	Rumbling.....		R. H. Thomas.

TABLE 2.—Instrumental seismological reports, September, 1915.

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols see this REVIEW, June, 1915, p. 289.]

Date.	Character.	Phase.	Time.	Period. T.	Amplitude.	Distance.	Remarks.
					A _E A _N		

Alaska. Sitka. Magnetic Observatory, U. S. Coast and Geodetic Survey. J. W. Green.

Lat., 57° 03' 00" N.; long., 135° 30' 06" W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{matrix} V & T_0 \\ E & 10 & 16.7 \\ N & 10 & 15.4 \end{matrix}$

1915.		H. m. s.	Sec.	μ	μ	Km.
Sept. 7	P _N	1 30 30	7			
	P _E	1 30 40				
	S _N	1 38 01	11			
	S _E	1 38 10				
	L _N	1 48 55	26			
	L _E	1 49 26	28			
	M _E	1 53 10	22	410		
	M _N	2 00 00	18		220	
	C.....	2 03 00	14			
	F.....	2 59 00				

Date.	Character.	Phase.	Time.	Period. T.	Amplitude.	Distance.	Remarks.
					A _E A _N		

Arizona. Tucson. Magnetic Observatory, U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 32° 14' 48" N.; long., 110° 50' 06" W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{matrix} V & T_0 \\ E & 10 & 16 \\ N & 10 & 19.6 \end{matrix}$

1915.		H. m. s.	Sec.	μ	μ	Km.
Sept. 7	P.....	1 26 37	6			
	S _E	1 31 16	12			
	S _N	1 31 30	6			
	L _E	1 35 06	13			
	L _N	1 35 11	11			
	M _E	1 38 23	16	2,280		
	M _N	1 41 42	16		1,170	
	C.....	1 43 00	14			
	F _E	2 23 00				
	F _N	3 05 00				
7	e.....	4 35 21	6			
	M _E	4 41 46	14	10		
	M _N	4 44 50	10		10	
	F _E	4 56 00				
	F _N	5 09 00				

Probably after effect of previous earthquake.

Date.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		

California. Berkeley. University of California.

Lat., 37° 52' 16" N.; long., 122° 15' 37" W. Elevation, 85.4 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. Mount Hamilton. Lick Observatory.

Lat., 37° 20' 21" N.; long., 121° 38' 34" W. Elevation, 1,281.7 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. Point Loma. Raja Yoga Academy. F. J. Dick.

Lat., 32° 43' 03" N.; long., 117° 15' 10" W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

(Instrument out of commission owing to repairs. See noninstrumental report.)

California. Santa Clara, University of. J. S. Ricard, S. J.

Lat., 37° 26' 36" N.; long., 121° 57' 03" W. Elevation, 27.43 meters.

(See Record of the Seismographic Station, University of Santa Clara.)

Colorado. Denver. Sacred Heart College. A. W. Forstall, S. J.

Lat., 39° 40' 36" N.; long., 104° 56' 54" W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

1915. Sept.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		
3	eP _N		7 52 00					Nothing on E-W.
	L _N		7 56 00					
	F _N		7 59 00					
5	eP _N		13 36 00					Only thickening of pen marks on N-S.
	M _N		13 38 00					
	F _N		13 40 00					
7	P _N		1 26 00					S doubtful owing to creases in and overlapping of paper. From 1 ^h 33 ^m on, all the waves are quite broken and irregular.
	S _N		1 30 00					
	L _N		1 31 00	10	68			
	M _N		1 32 00	10		69		
	M _N		1 33 00	10-12		143		
	M _N		1 35 00	10-12	143			
	C _N		1 46 00	10-15	25	25		
	F _N		2 17 00					
27	eL _N		6 57 00	20-30				Activity on 13, 16-17, and 25.
	F _N		6 59 00					

District of Columbia. Washington. U. S. Weather Bureau.

Lat., 38° 54' 12" N.; long., 77° 03' 03" W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants. $V \quad T_0$
110 6

1915. Sept.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		
7	iP _N		1 26 32				3,070	Severe earthquake off the Pacific coast of Central America.
	S _N		1 31 20					
	M _N		1 34 30		364			
	L _N		1 35 35					
	L _N		1 37 00	16				
	M _N		1 37 05			500		
	L _N		1 46 55	12				
	F _N							
7	P _N		4 29 18				2,910?	Many other large maxima. (Pendulum undamped.) F merges in subsequent disturbance.
	S _N		4 33 54					
	L _N		4 38 38					
	L _N		4 41 30	12				
	M _N		4 42 30					
	F _N		5 00 00					
7	P _N		5 04 18				2,990?	L possibly in part due to circum-terrestrial waves from preceding earthquake.
	S _N		5 09 00					
	L _N		5 13 36					
	L _N		5 17 30	12				
	F _N		5 30 00					
7	P _N		5 37 22					
	S _N		5 41 38					
	L _N		5 46 32					
	F _N		5 55 00					

Date.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		

District of Columbia. Washington—Continued.

1915. Sept.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		
7	I _r	P	6 13 36				3,030	L, doubtful.
	I _r	S	6 18 21					
	I _r	L	6 25 00					
	I _r	F	6 25 00					
7	I _r	P	12 53 42					
	I _r	S	12 58 06					
	I _r	L	13 07 00	12				
	I _r	F	13 30 00					
7	I _r	P	20 45 06					
	I _r	S	20 49 38					
	I _r	L	20 54 36					
	I _r	F	21 30 00	10				
12	I _u	P	20 52 17				5,275	F lost in microseisms.
	I _u	S	20 59 14					
	I _u	L	21 05 36					
	I _u	F						

District of Columbia. Washington. Georgetown University. F. L. Tondorf, S. J.

Lat., 38° 54' 25" N.; long., 77° 04' 24" W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg., astatic horizontal pendulums, 80 kg., vertical.

Instrumental constants. $V \quad T_0$
E 165 5.4 2.6
N 143 5.2 3.4
Z

1915. Sept.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		
7	III _r	eP _E	1 26 27		4			VERTICAL.
	III _r	eP _N	1 26 32		4			
	III _r	S _E	1 31 12	10				
	III _r	S _N	1 31 20	9				
	III _r	L _N	1 34 36	40		304		
	III _r	L _E	1 34 40	40	345			
	III _r	M _E	1 37 11	20	466			
	III _r	M _N	1 37 16	20		713		
	III _r	F _E	2 2 18					
	III _r	F _N	2 45 22					
		eP _E	1 26 33					* Trace amplitude.
		iP _E	1 26 44					
		L _E	1 35 07	10	*17,400			
		M _E	1 37 24	20	*45,900			
		F _E	2 46 50					

* Trace amplitude.

Hawaii. Honolulu. Magnetic Observatory. U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19' 12" N.; long., 158° 03' 48" W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant. T_0
18.9

1915. Sept.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		
3		eL _N	23 22 18	23				
		M _N	23 30 18			*200		
		C _N	23 37 00					
6		S _N	17 42 54					
		L _N	17 44 54	21				
		M _N	17 49 18			*1,200		
		C _N	17 57 30					
		F _N	19 07 18					
7		P _N	1 31 36					
		S _N	1 40 30					
		M _N	1 41 12			*4,000		
		L _N	1 50 48	23				
		M _N	1 54 06			*3,200		
		C _N	2 01 24			*3,200		
12		P _N	2 38 24					
		F _N	6 16 12					
15		eL _N	22 26 48					
		M _N	22 29 12	18		*100		
		F _N	22 32 36					
28		eL _N	9 46 48					
		M _N	9 49 30	18		*100		
		F _N	9 55 30					

* Trace amplitude.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude.		Distance.	Remarks.
					A _E	A _N		

Kansas. Lawrence. University of Kansas. Department of Physics and Astronomy. F. E. Kester.

Lat., 35° 57' 30" N.; long., 95° 14' 58" W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants.. $\begin{matrix} V & T_0 & \epsilon \\ \text{E} & 177 & 3.7 & 4.0 \\ \text{N} & 205 & 3.7 & 3.8 \end{matrix}$

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 7	P.	-----	1 26 13	2-3	10	28	-----	Beginning of L not discernible.
			1 30 38	4-5	35	58	-----	
			1 30 38	4-5	35	58	-----	
			3 00 00	20-30	31	19	-----	

Maryland. Cheltenham. Magnetic Observatory. U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 33° 44' 00" N.; long., 76° 50' 30" W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants.. $\begin{matrix} V & T_0 \\ \text{E} & 10 & 31 \\ \text{N} & 10 & 29 \end{matrix}$

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 7	P.	-----	1 26 40	4	-----	-----	-----	Probably connected with the preceding earthquake. Nothing on N-S.
			1 31 25	6	-----	-----	-----	
			1 35 01	12	-----	-----	-----	
			1 35 38	13	-----	-----	-----	
7	e _N	-----	1 37 12	20	290	1700	-----	
			2 43 00	-----	-----	-----	-----	
			3 05 00	-----	-----	-----	-----	
			4 38 10	10	-----	-----	-----	
7	M	-----	4 46 55	10	-----	-----	-----	
			4 57 00	-----	-----	-----	-----	

¹ Amplitude probably greater, as stylus passed off the sheet.

Massachusetts. Cambridge. Harvard University Seismographic Station. J. B. Woodworth.

Lat., 42° 22' 36" N.; long., 71° 06' 59" W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums, undamped (mechanical registration).

(Report for September, 1915, not received.)

Missouri. Saint Louis. Saint Louis University. Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38' 15" N.; long., 90° 13' 58" W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. $\begin{matrix} V & T_0 & \epsilon \\ \text{E} & 80 & 7 & 5:1 \end{matrix}$

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 7	III _r	eP _E	1 26 12	-----	-----	-----	3,200	
			1 26 36	-----	-----	-----	-----	
			1 27 06	-----	-----	-----	-----	
			1 31 00	-----	-----	-----	-----	
7	L	-----	1 33 12	-----	-----	-----	-----	
			1 36 30	-----	20	-----	-----	
			1 37 00	-----	-----	28	-----	
			2 10 00	-----	-----	-----	-----	
7	e _N	-----	4 28 54	-----	-----	-----	-----	
			4 53 00	-----	-----	-----	-----	
7	e _N	-----	5 04 00	-----	-----	-----	-----	
			5 23 00	-----	-----	-----	-----	
7	e _N	-----	12 52 48	-----	-----	-----	-----	
			13 14 00	-----	-----	-----	-----	
7	e _N	-----	20 46 36	-----	-----	-----	-----	
			21 06 00	-----	-----	-----	-----	

Date.	Character.	Phase.	Time.	Period. T.	Amplitude.		Distance.	Remarks.
					A _E	A _N		

New York. Buffalo. Canisius College. John A. Curtin, S. J.

Lat., 42° 53' 02" N.; long., 78° 52' 40" W. Elevation, 190.5 meters.

Instrument: Wiechert, 80 kg. horizontal.

Instrumental constants.. $\begin{matrix} V & T_0 & \epsilon \\ \text{E} & 80 & 7 & 5:1 \end{matrix}$

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 7	II _r	eP _E	1 24 26	-----	-----	-----	4,000	Reported in Central America.
			1 24 30	-----	-----	-----	-----	
			1 29 30	6	-----	-----	-----	
			1 32 40	38	-----	125	-----	
		L _E	1 32 50	45	125	-----	-----	Amplitude of N-S pen limited.
			1 34 00	10	625	-----	-----	
			1 35 00	-----	-----	150	-----	
			1 35 00	-----	-----	-----	-----	
24		C _E	1 35 00	-----	-----	-----	-----	Tremors on E-W.
			2 08 00	-----	-----	-----	-----	
27		F _E	2 53 00	-----	-----	-----	-----	Tremors on E-W.
			2 53 00	-----	-----	-----	-----	

New York. Fordham. Fordham University. W. C. Repetti, S. J.

Lat., 40° 51' 47" N.; long., 73° 53' 08" W. Elevation, 23.9 meters.

Instrument: Wiechert, 80 kg.

Instrumental constants.. $\begin{matrix} V & T_0 & \epsilon \\ \text{E} & 72 & 7.2 & 1.5:1 \\ \text{N} & 72 & 7.2 & 3.8:1 \end{matrix}$

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 6	L _N	-----	18 37 30	-----	-----	-----	-----	
			1 22 27	5	-----	-----	-----	
			1 27 37	-----	-----	-----	-----	
			1 31 01	-----	-----	-----	-----	
7	L _E	-----	1 31 21	-----	-----	-----	-----	
			1 34 31	15	583	-----	-----	
			1 34 36	12	-----	444	-----	
			2 20 00	-----	-----	-----	-----	
7	F _E	-----	2 55 00	-----	-----	-----	-----	
			4 37 00	-----	-----	-----	-----	

Panama Canal Zone. Balboa Heights. Isthmian Canal Commission.

Lat., 8° 57' 39" N.; long., 79° 33' 29" W. Elevation, ---.

Instruments: Two Bosch-Omori, 100 kg.

Instrumental constants.. $\begin{matrix} V & T_0 \\ \text{E} & 10 & 20 \end{matrix}$

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 7	III _r	P _E	1 23 19	-----	-----	-----	-----	Direction NW.
			1 23 26	-----	-----	-----	-----	
			1 25 45	-----	-----	-----	-----	
			1 25 48	-----	-----	-----	-----	
	L _E	-----	1 26 58	-----	-----	-----	-----	
			1 26 59	-----	-----	-----	-----	
			1 27 33	-----	2,300	-----	-----	
			1 27 52	-----	-----	3,150	-----	
	M _E	-----	2 23 16	-----	-----	-----	-----	
			2 24 18	-----	-----	-----	-----	
			6 14 10	-----	-----	-----	300	Direction SW?
			6 14 46	-----	-----	-----	-----	
17	L _E	-----	6 14 50	-----	20	-----	-----	
			6 15 00	-----	-----	20	-----	
			6 16 30	-----	-----	-----	-----	
			6 16 30	-----	-----	-----	-----	
20	L _E	-----	1 09 38	-----	-----	-----	240	
			1 10 06	-----	-----	-----	-----	
			1 10 10	-----	50	-----	-----	
			1 10 11	-----	-----	80	-----	
	F _E	-----	1 11 20	-----	-----	-----	-----	
			1 11 38	-----	-----	-----	-----	
23	L _E	-----	7 54 46	-----	-----	-----	170	Direction probably SW.
			7 54 52	-----	-----	-----	-----	
			7 55 04	-----	-----	-----	-----	
			7 55 10	-----	-----	-----	-----	
	M _E	-----	7 55 04	-----	200	-----	-----	
			7 55 14	-----	-----	300	-----	
			7 56 35	-----	-----	-----	-----	
			7 56 40	-----	-----	-----	-----	

Date.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		

Porto Rico. Vieques. Magnetic Observatory. U. S. Coast and Geo-
detic Survey. H. M. Pease.

Lat., 18° 09' N.; long., 65° 27' W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants. $\begin{cases} E & V & T_0 \\ N & 10 & 21.4 \\ & 10 & 21.1 \end{cases}$

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 7		P	1 25 57	7				N-S not recording.
		S	1 27 57	5				
		L	1 30 15	9				
		M	1 34 53	10	1 750			
		C	1 50 00	9				
		F	2 18 00					

¹ Maximum amplitude probably greater, as the stylus went off the paper.

Vermont. Northfield. U. S. Weather Bureau. Wm. A. Shaw.

Lat., 44° 10' N.; long., 72° 41' W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants. $\begin{cases} E & V & T_0 \\ N & 10 & 15 \\ & 10 & 16 \end{cases}$

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 7	III,	P	1 27 24				3,435	
		S	1 32 37					
		L	1 36 38					
		M _N	1 43 00			160		
		M _E	1 44 00		1 600			
		F	4 00 00					
7		P?	4 31 19					
		C _N	4 38 20					
		L _N	4 46 30					
		F _N	5 00 00					
12		M	20 59 30					Disturbance slight; phases uncertain.
		F	21 20 00					

¹ Approximate, pen ran off sheet.

Date.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		

Canada. Ottawa. Dominion Astronomical Observatory. Earthquake
Station. Otto Klotz.

Lat., 42° 23' 38" N.; long., 75° 42' 57" W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer
80 kg. vertical seismograph.

Instrumental constants. $\begin{cases} V & T_0 \\ 120 & 26 \end{cases}$

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 6		e	17 50 27					
		L _E	17 54 00	20				
		L _E	18 00 00	20				
		L _N	18 15 00	12				
		L	18 25 to	20-14				
		L	18 54 00					
		F	19 15 00					
7		P	1 27 27	2			3,760	
		PRL	1 27 58					
		S	1 33 00					
		L	1 36 06	40				
		M _N	1 40 06	30		1,830		
		M _E	1 39 to	30	1,800			
		L	1 40 30	40				
		L	1 51 00					
		L	2 03 00	16-13				
		F	2 55 00					

F merges in another
quake.

VERTICAL.

			H. m. s.	Sec.	μ	μ	Km.	
		eP	1 27 29					
		iP	1 27 38					
		eL	1 36 30					
		L	1 39 00	34				
		M	1 40 30	26	3,600			
		L	1 50 00	12				
		F	1 55 00					
7		P	4 35 27				3,750?	
		L	4 44 00	12				
		L	4 48 00	12				
		F	5 10 00					
7		P	5 10 30				3,750?	
		L	5 19 00	15-13				
		L	5 26 00	13				
		F	5 35 00					
7		e _E ?	12 55 31				3,750?	
		L _N	12 59 50					
		L	13 07 00	20-15				
		F	13 25 00					
7		P	20 46 04				3,750?	P and S not pro- nounced.
		S _N	20 51 26					
		S _E	20 51 48					
		L _E	20 54 30	10				
8		L	20 54 48	10				
		L	21 00 00	20-13				
		L	21 06 00	16-14				
		F	21 20 00					
12		eL _E	12 48 00	12				
		eL _N	12 52 00	12				
		P	20 52 39	2			5,530	
		S	20 59 50	6				
		eL	21 05 06	20				
		L	21 08 00	20				
		F	21 25 00					

Date.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		

Canada. Toronto. Dominion Meteorological Service.

Lat., 43° 40' 01" N.; long., 79° 23' 54" W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrument constant: T_0 Pillar deviation, 1 mm. swing of boom=0.59".

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 6	L		18 11 12					Earlier record lost through attending to instrument.
	L		18 17 18					
	L		18 23 24					
	M		18 24 45		*200			
	L		18 48 00					
7	P		1 27 48				3,500	Very large earthquake disturbance, origin in Pacific off Central America
	S		1 32 42					Magnetometers at the Agincourt Observatory affected.
	L		1 34 36					
	L		1 38 54					
	M		1 39 54		*39,000			
	M		1 41 24		*37,500			
	L		1 50 12					
	L		1 54 36					
	M		1 57 06		*7,000			
	L		2 00 54					
	L		2 11 42					
	M		2 13 42		*4,000			
	L		2 40 42					
	L		2 50 18					
	F							Trailers and F merge into next earthquake.
7	L		4 06 48					
	L		4 10 12					
	L		4 41 12					
	M		4 44 00		*900			
	L		4 58 00					
	L		5 14 24					
	F							F merges into following quake.
7	P		5 41 00					P mixed up with trailers of preceding quake.
	S		5 47 18					
	L		5 49 42					
	M		5 51 18		*300			
	F		6 02 00					
7	P?		13 00 00					P doubtful, air currents going on.
	IL		13 06 06					
	M		13 07 12		*200			
	L		13 15 24					
	F		13 30 54					
7	L		20 59 24					
	M		21 02 30		*200			
	F		21 18 24					
8	L		12 45 42					
	L		12 53 24		*50			
12	IP		20 59 54					Marked quake.
	S?		21 07 00					
	IL		21 09 54					
	M		21 13 00		*500			
	F		21 57 06					
16	L		10 46 06					Marked thickening.
	M		10 48 18		*100			
	F		10 54 30					
17	S or L		5 22 30					
	L		5 25 24					
	M		5 32 00		*300			
	L		5 40 18					
	F		6 00 18					
23	L		13 35 42					Air currents going on.
	L		13 39 00					
28	S or L		10 09 18					Gradual thickening before M.
	L		10 13 54					
	M		10 16 12		*200			
	F		10 20 48					

*Trace amplitude.

Date.	Char-acter.	Phase.	Time.	Period. T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		

Canada. Victoria, B. C. Dominion Meteorological Service.

Lat., 48° 24' N.; long., 123° 19' W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant: T_0 Pillar deviation, 1 mm. swing of boom=0.54".

1915.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 6	P		17 48 01				10,310	
	S		17 59 13					
	L		18 01 43					
	M		18 08 43		*750			
	F		19 05 43					
7	P		1 29 14				4,770	
	S		1 33 44					
	L		1 38 44					
	L		1 41 54					
	L		1 46 06					
	M		1 49 14		*10,000			
	L		1 55 18					
	L		2 19 24					
	F		4 08 44					
7	P		4 38 44				6,440	
	S		4 46 44					
	L		4 52 44					
	M		4 53 44		*900			
	F		?					
7	P		5 28 44					
	S		?					
	M		5 30 44		*400			
	F		5 36 44					
7	P		13 03 46					
	L		13 14 46					
	M		13 16 16		*100			
	F		13 33 46					
7	L		21 05 48					
	F		21 14 48		*50			
12	P?		21 12 54					
	S?		21 22 28					
	L		21 26 38					
	L		21 27 58					
	M		21 34 58		*250			
	F		22 15 58					
16	P		10 46 06				130	Origin may be in State of Washington.
	S or L		10 46 21					
	M		10 47 06		*200			
	F		10 49 36					
17	L		5 02 07					Pronounced disturbance.
	M		5 08 37		*1,500			
	F		5 56 42					
23	P		9 20 12					
	L		9 29 05					
	M		9 36 00		*200			
	F?		9 46 54					
25	P		13 53 54					
	L		13 57 54					
	M		13 58 24		*200			
	F		14 01 54					
28	P		9 48 04					
	L		9 51 04					
	M		9 53 04		*100			
	F		9 57 34					

*Trace amplitude.

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

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- Australia.** Commonwealth bureau of meteorology. Chart showing the drift of ocean current papers, [with table of particulars extracted from ocean current papers returned to Commonwealth meteorological bureau. 1915. chart 38 x 56 cm. Rain map of Australia for the year 1914, [and] maps showing the average district rainfall for each month during 1914. 1915. chart 56 x 72½ cm.
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- Herbertson, A. J., & Howarth, O. J. R., editors.** The Oxford survey of the British Empire. Oxford. 1914. 6 v. 23 cm. [v. 1, British Isles; v. 2, Asia; v. 3, Africa; v. 4, America; v. 5, Australasia; v. 6, General survey. Volumes 1 to 5 contain chapters on climate.]
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India. Meteorological Department.

Memorandum on the monsoon conditions prevailing during June and July, with a forecast for August and September, 1915, by G. C. Simpson. Simla. 1915. 3 p. 33 cm.

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Bulletin hydrographique pour l'année juillet 1913-juin 1914. Copenhagen. 1915. v. p. plates. 32½ cm.

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Lyon, G. J.

Equipment for current-meter gaging stations. Washington. 1915. 64 p. 37 pl. 23 cm.

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The formation of ozone in the upper atmosphere, and its influence on the optical properties of the sky. (In Science progress, London, January, 1915, v. 9, p. 448-470.)

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C. FITZHUGH TALMAN, Professor in Charge of Library.

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SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. DAY, Climatologist and Chief of Division.

(Washington, Oct. 3, 1915.)

PRESSURE.

The distribution of the mean atmospheric pressure over the United States and Canada and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the barometric pressure was near or slightly above the normal over the sections to eastward of the Mississippi River, except along the coastal portions of New England and over the eastern Canadian Provinces. It was also above the normal over the upper Mississippi and middle and upper Missouri valleys and near the north Pacific coast. Over all other portions of the country the means for the month were below the normal, the greatest minus departures appearing in the central Rocky Mountain region and the Canadian Maritime Provinces.

The month opened with relatively high pressure over the eastern portion of the country, while in the Northwest low pressure obtained. Pressure continued high throughout most eastern districts during the next few days, after which it was generally below the normal until near the end of the first decade, due to the passage of a subtropical storm across this region. Elsewhere the pressure was near or slightly above the normal, except in the Northwest, where it was generally low.

During the second decade the pressure was above the normal over most northern and eastern districts, except in the extreme Northeast, where it was generally low. Elsewhere it was near or slightly below the normal.

Throughout the greater part of the third decade, relatively high pressure prevailed over most central and eastern districts, but in other sections it was generally low, due to the occurrence of rather extensive and well-defined depressions at frequent intervals during the latter part of the month. At the close abnormally low pressure prevailed throughout the southeastern districts, due to the appearance of a severe subtropical storm in that region, full details of which appear elsewhere, but over most northern districts from the Rocky Mountains to the lower Lakes the pressure was generally moderately high, while in the eastern Canadian Provinces and the extreme Northwest it was relatively low.

The distribution of the highs and lows was favorable for southerly and southwesterly winds in the great central valleys, the Lake region, and the New England States, northwesterly in the coastal portion of the Middle Atlantic States, northeasterly in the South Atlantic and east Gulf States, except over the southern Florida Peninsula, where they were easterly, southerly, and southeasterly in the west Gulf States, and northerly and northwesterly along the Pacific coast.

TEMPERATURE.

The month opened with low temperatures over the Central States, but within a few days they had risen to near the normal in nearly all districts and seasonable weather very generally prevailed in all parts of the country until the close of the first week. The mean temperatures for the week were above the normal throughout the Northern States and along the Pacific coast, the first time in more than three months that the weekly mean temperatures were above the normal to an appreciable extent between the Great Lakes and the Rocky Mountains. At the same time temperatures in the South were below the normal, the week being the first there for a considerable period with average temperatures below the normal to any considerable degree.

Throughout the second week warm and oppressive weather prevailed in the central, eastern, and southern districts, but in the Northwest the week was decidedly cool for the season. Over all districts from the upper Mississippi to the southern Rocky Mountains and to the eastward the mean temperatures for the week were above normal, the daily departures ranging from 10° to 12° in the Middle Atlantic States. Elsewhere the weekly means were below the normal, the minus departures being from 15° to 17° per day in portions of Montana.

During the early days of the third week warm weather continued over the central and eastern districts, and it remained cool in the mountains and far West, but with a tendency to warmer as the week advanced. Warm weather continued in the East and South until shortly after the middle of the week, when temperatures near the normal prevailed. During the latter part of the week cooler weather overspread the northwestern districts, which by the end had extended into the central valleys, and frost occurred in the upper Mississippi Valley and northern Plains States.

The mean temperatures for the week were unseasonably high in the more eastern districts, the averages exceeding the normal by 10° to 15° per day from central Virginia northeastward to New England. The week was cool in the northern Plains States and over much of the Rocky Mountain district, while over the Pacific Coast States the temperature was somewhat above the normal.

During the first few days of the fourth week cooler weather overspread the eastern and southern districts, with frost in the interior of the Middle Atlantic and New England States, while from the Plains region westward moderately warm weather prevailed and by the middle of the week a general warming up was in evidence in all sections except in the Lake region and Pacific coast districts, where lower temperatures obtained. Toward the latter part of the week cooler weather had overspread the Plateau and Mountain regions and nearly all eastern districts.

During the last few days of the month cool weather prevailed over the northern half of the country and in the Rocky Mountain and Plateau districts, with local frosts in the region of the Great Lakes, New England, and the

interior of the Middle Atlantic States, but in the South more seasonable temperatures prevailed. The mean temperatures for the last nine days of the month as a whole were below the normal from the Lake region and Ohio Valley eastward to the Atlantic coast, while over other portions of the country they were generally near the normal, although in most southern districts the weather was moderately warm, and it was very generally cool in the Missouri Valley and the Great Valley of California.

PRECIPITATION.

During the first few days of the month fair weather obtained generally throughout the country, except for a few local showers in the Southeastern States and occasional rains to the westward of the Rocky Mountains. About the middle of the week a tropical storm moved from the Gulf to the upper Lake region, attended by high winds and shifting gales along the coast, with considerable damage to crops and other property, while precipitation occurred over most of the districts to the eastward of the Mississippi River. Over other sections of the country showers at scattered points were reported, and the week closed with local rains in the Missouri Valley, the region of the Great Lakes, and at a few points in the Atlantic Coast States, but elsewhere fair weather was general.

For the week as a whole fairly heavy rains fell in the South Atlantic and East Gulf States and thence northward to the lower Lake region, and showers occurred at points in the central and lower Missouri Valley, but elsewhere to the eastward of the Rockies little rain fell during the week, large areas receiving none. Showers occurred over considerable areas in the Rocky Mountain districts and along the extreme north Pacific coast, but over other districts to the westward of the mountains little or no rain fell.

The second week opened with showery weather over the northern States from New England westward to the Pacific and also in the lower Missouri and middle Mississippi valleys, but elsewhere it continued fair. About the middle of the week heavy rains occurred in the region of the Great Lakes and the upper Mississippi Valley, but elsewhere the weather continued fair save for widely scattered local showers. During the latter part of the week rain again occurred quite generally over northern districts from New England nearly to the Pacific coast, with heavy local falls in Michigan and the upper Mississippi Valley.

From the Dakotas eastward to the Great Lakes and thence southward to northern Oklahoma the rainfall for the week as a whole was generous to heavy, ranging mostly from about 2 to 4 inches, while in portions of Ohio and Indiana about 1 inch occurred. Elsewhere to the eastward of the Rocky Mountains but little rain fell, and in large areas, particularly from Texas northeastward to the southern drainage of the Ohio, no precipitation occurred. To the westward of the Rocky Mountains rainfall occurred over the northern districts, but otherwise the week was practically rainless.

At the beginning of the third week scattered showers and thunderstorms occurred at many points to the eastward of the Rockies, the rainfall being moderately heavy locally in Texas and the lower Missouri and the upper Mississippi valleys. During the middle portion of the week unsettled, showery weather obtained in many eastern districts, with some rather heavy rains locally in the central Plains States and the Ohio Valley. Toward the latter part of the week moderate showers occurred over most districts to the eastward of the Plains States, but at the close generally

fair weather obtained in all portions of the country except over the middle Atlantic coast and from the Lake region eastward.

Rainfall occurred at some time during the week in nearly all districts to the eastward of the Rocky Mountains, but the totals were mostly light, although fairly heavy amounts, ranging from 2 to 4 inches, occurred over the lower Missouri, the upper and middle Mississippi valleys, and portions of Illinois and Indiana, while like amounts occurred in more local areas in Texas, Arkansas, and the Florida Peninsula. In the districts to the westward of the Rocky Mountains the week was rainless, except for a few light and widely scattered showers.

During the first few days of the fourth week fair weather obtained over the districts to the eastward of the Rocky Mountains, except for local showers in the Atlantic and Gulf coast sections, which were heavy in parts of Texas, 8.62 inches of rainfall occurring at Corpus Christi within 48 hours. About the middle of the week showers occurred in the west Gulf States, the Northwest, and the region of the Great Lakes, and toward the latter part general rains obtained from the Plateau district eastward over the central and northern districts to the Atlantic. In the South, to the eastward of the Mississippi, the weather continued fair, except that showers occurred over the Florida Peninsula.

During the last few days of the month a tropical storm moved inland near the mouth of the Mississippi, accompanied by heavy rains and winds of hurricane force. Many lives were lost in the lowland districts of the Louisiana and Mississippi coasts and in the vicinity of New Orleans, and the damages to buildings and crops were extensive. After passing inland the storm rapidly diminished in force and moved slowly northeastward. (See also p. 456-466.) During the occurrence of this storm only light rains fell in other districts, mostly in the Northwest.

The rainfall, as a whole, for the last nine days of the month was heavy in the upper Mississippi and middle Missouri valleys, and over the southern States generally, while over the New England and Middle Atlantic States, along the Canadian border, and to the westward of the Rocky Mountains the amounts were small.

GENERAL SUMMARY.

The weather for September, 1915, was characterized by almost continuous warmth over the eastern half of the country, which was in marked contrast to the nearly continuous low temperatures over the northern and central portions for several preceding months, the departures for the month averaging from 3° to 6° above the normal over large areas of this section. Rain fell over practically all portions of the country except a small area of the central coastal portion of California, and the falls were heavy over portions of the Gulf States, eastern Tennessee, and a narrow belt from northwestern Texas northeastward to the Upper Lakes.

STORM OF AUGUST 1-2, 1915, IN FLORIDA.

The following notes on the storm of August 1-2, 1915, have been extracted from the report of the section director, Jacksonville, Fla., received too late for publication in the August REVIEW:

A storm of considerable energy, attended by torrential rains over portions of the Peninsula, approached the east coast of Florida between Titusville and Jupiter during the forenoon of August 1. The winds throughout the Peninsula indicated a disturbance to the southeast of

Cape Canaveral. On the evening of the 1st the pressure at Titusville was 29.72 inches and the 24-hour rainfall 3.34 inches. The storm center was about 25 miles west of Jacksonville at 7 a. m. of the 2d, with a maximum wind velocity at the latter place of 54 miles, and an average hourly movement of nearly 38 miles for the preceding 12 hours. The American steamship *Vann* ran into the storm off Cape Canaveral about 9 a. m., August 1, wind about 60 miles southeast, barometer 29.57 inches. The high winds were confined, as a rule, to the portion of the Peninsula east of the Suwanee River, while damaging rains extended over the triangular area from Pinellas County on the west coast to Jacksonville and Hypoluxo on the east coast, rainfall intensity being greatest apparently at St. Petersburg, where 15.45 inches fell in 24 hours. An electrical disturbance of great intensity was coincident with the heavy rains. The damage was chiefly to railway tracks, bridges, highways, and other such structures. Some buildings were blown down, but no one was reported to have been killed. Crops on lowlands suffered severely, and even those on high ground did not escape the consequence of heavy rains and a prolonged soggy condition of the soil. The area of greatest damage was over portions of Pinellas, Hillsboro, Manatee, De Soto, Polk, Palm Beach, St. Lucie, and Brevard counties. Summarized press reports show that the total damage was not less than \$250,000.

Average accumulated departures for Sept., 1915.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	General mean for the current month.	Departure for the current month.
	°F.	°F.	°F.	Ins.	Ins.	Ins.	0-10	P.ct.		
New England.....	63.9	+3.2	+9.5	1.07	-2.10	-3.20	4.4	-0.8	71	-10
Middle Atlantic.....	69.5	+3.0	+7.3	2.10	-1.40	-0.90	4.4	-0.2	77	0
South Atlantic.....	75.9	+2.8	+0.4	3.17	-1.80	-5.80	4.4	-0.3	80	0
Florida Peninsula.....	81.7	+0.9	-8.2	4.96	-3.00	-3.70	5.2	-0.2	78	-3
East Gulf.....	78.0	+3.2	+1.0	4.72	+0.80	-3.20	4.4	-0.2	78	-2
West Gulf.....	78.1	+2.4	-5.2	2.76	-0.70	-3.30	4.7	+0.5	78	+4
Ohio Valley and Tennessee.....	65.4	+2.2	-5.4	3.84	+1.30	-1.40	4.5	+0.1	77	+5
Lower Lakes.....	65.3	+2.2	-3.1	3.69	+0.90	+0.10	4.9	+0.1	78	+5
Upper Lakes.....	60.7	+1.5	+3.8	4.42	+1.10	-0.40	5.7	+1.5	82	+5
North Dakota.....	55.3	-1.9	+8.1	1.93	+0.50	-0.60	5.8	+1.4	78	+15
Upper Mississippi Valley.....	66.4	+1.5	-2.9	5.20	+2.30	+6.90	5.4	+1.1	81	+9
Missouri Valley.....	65.7	+0.4	-8.0	4.48	+1.80	+8.50	4.9	+0.9	78	+12
Northern slope.....	54.2	-3.3	-2.1	2.16	-1.10	+2.80	5.9	+1.9	70	+15
Middle slope.....	67.8	+0.3	-12.2	3.11	+1.20	+7.80	4.7	+1.3	71	+13
Southern slope.....	73.5	+0.7	-11.4	3.22	+0.60	+3.40	4.2	+0.4	68	+5
Southern Plateau.....	72.1	-1.4	-17.2	0.19	0.00	+1.50	2.0	-0.5	48	+9
Middle Plateau.....	60.9	-1.4	-2.9	0.88	+0.20	-0.40	2.9	0.0	41	+3
Northern Plateau.....	59.5	-1.7	+12.8	0.72	-0.10	+0.20	4.6	+1.0	47	-5
North Pacific.....	57.8	+0.9	+20.3	0.87	-1.60	-7.70	5.5	+0.2	79	+7
Middle Pacific.....	63.3	-0.1	+6.6	0.02	-0.50	+4.20	2.2	-1.2	59	-8
South Pacific.....	67.9	+0.6	+10.8	T.	-0.20	+3.70	2.4	-0.2	68	+2

Maximum wind velocities, Sept., 1915.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mis./hr.				Mis./hr.	
Block Island, R. I.	26	60	nw.	New York, N. Y.	17	72	w.
Do.	27	60	nw.	Do.	21	58	nw.
Buffalo, N. Y.	21	50	nw.	Do.	26	72	nw.
Do.	26	72	sw.	Do.	27	54	nw.
Burlington, Vt.	26	50	nw.	Pensacola, Fla.	29	60	se.
Duluth, Minn.	25	50	nw.	Do.	30	64	s.
Green Bay, Wis.	8	54	sw.	Point Reyes Light, Cal.	12	55	nw.
Mobile, Ala.	29	61	se.	Do.	13	54	nw.
Mount Tamalpais, Cal.	12	64	nw.	Do.	22	50	nw.
Do.	13	56	nw.	Do.	23	72	nw.
Do.	17	60	nw.	Do.	24	57	nw.
Do.	18	59	nw.	Portland, Me.	27	50	nw.
Do.	19	60	n.	Providence, R. I.	26	62	nw.
Do.	23	80	n.	Sandy Hook, N. J.	26	51	nw.
Do.	24	67	nw.	Sand Key, Fla.	3	54	se.
Nantucket, Mass.	26	59	sw.	Do.	27	58	se.
New Orleans, La.	29	86	se.	Toledo, Ohio.	10	52	w.

WEATHER CONDITIONS OVER THE NORTH ATLANTIC DURING SEPTEMBER, 1914.

P. C. DAY, Climatologist and Chief of Division.

The data presented are for September, 1914, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month. The accompanying Chart IX (XLIII-111) shows for September, 1914, the averages of pressure, temperature, and the prevailing direction of the winds, together with the location and course of the more severe storm tracks of the month. During the month as a whole the distribution of mean atmospheric pressure over the greater part of the ocean was similar to the normal as shown on the Meteorological Chart of the North Atlantic Ocean for September. The Azores high was of normal intensity and position, but of slightly less area than usual. The center of the Icelandic low is not shown on account of lack of observations, but as far as can be judged, it was probably some distance southwest of its normal position. The variations in pressure were marked during the month over the northeastern part of the ocean, as off the west coast of Scotland the barometer readings varied from 29.21 inches on the 14th to 30.40 inches on the 29th, while in the central and southern portions the range was much less. Only two storm tracks could be shown, although on several days disturbances occurred, accompanied by heavy winds, whose centers it was impossible to plot, due to want of data.

On September 2 the British steamship *Megantic* reported a northwest gale of 56 miles an hour, barometer reading of 29.29 inches at latitude 54° N., longitude 48° W., the vessel being about 3° south of the apparent center of the low. By the following day this disturbance was central near latitude 53° N., longitude 37° W., west and northwest winds of 48 miles being reported, and on September 4 and 5 the track of the low could be traced in its easterly movement, as on the latter date the center was near latitude 51° N., longitude 21° W., while the wind had decreased to a moderate breeze and the barometer risen to 29.80 inches. On September 17 a low appeared near latitude 47° N., longitude 41° W., several vessels reporting winds of from 48 to 56 miles an hour. By the 18th it had moved in a westerly direction to latitude 45° N., longitude 49° W., the velocity of the wind remaining about the same. From this point the storm recurred, and on the 19th was central near latitude 47° N. and longitude 45° W., the wind having decreased in violence. By the 20th it had apparently moved some distance to the northward, and while it was impossible to plot the center on account of the lack of observations, a vessel near latitude 50° N., longitude 40° W., reported a northwest wind of 54 miles an hour, the barometer reading 29.50 inches. This is shown as track I on Chart No. 9. On September 24 a low of comparatively light intensity appeared near Pensacola, Fla. This moved slowly along the coast, and on the 25th the center was near Charleston, but the wind still remained light. From this point the storm increased in intensity and in rate of movement, and on September 26 was near latitude 40° N., longitude 68° W. On the 27th it was near latitude 51° N., longitude 50° W., having decreased in intensity, and by the 28th had moved off the limits of the chart. This is shown as track II on Chart No. IX.

Fog.—Observations of fog in September for the 6-year period 1901 to 1906, as given on the Meteorological Chart of the North Atlantic Ocean for September, show that the greatest percentage of days for the above period on which fog was observed occurred in the vicinity of the Banks of Newfoundland, the center of the area being near latitude 47° N., longitude 48° W. Here the percentage was given

as from 30 to 35, while for September, 1914, in the five-degree square from latitude 45° to 50° N. and longitude 45° to 50° W. fog was observed on 8 days, or a percentage of 27. The normal percentage for the square from latitude 45° to 50° N. and longitude 25° to 30° W. varies from 20 to 25, while for the month under discussion it was only 10. In the square from latitude 55° to 60° N. and longitude 15° to 20° W. it was 3 and the normal 5, showing that taken as a whole the amount of fog along the northern sailing routes was somewhat below the normal.

Temperature.—The temperatures were very generally above normal over the North Atlantic during the month, with the greatest positive departures along the European coast where they ranged from $+6^{\circ}$ off the coast of Scotland to $+2^{\circ}$ at the thirtieth parallel of latitude. Over the waters adjacent to the American coast the departures were less and over the adjacent land areas they varied from $+2.5^{\circ}$ at Eastport to -0.3° at New York, -2.3° at Atlantic City, -2.7° at Hatteras, -0.1° at Jacksonville, and -0.5° at Key West. There was as usual rain nearly every day over some portions of the trans-Atlantic routes, though no hail or snow was reported during the month.

A PACIFIC HURRICANE OF SEPTEMBER, 1915.

By JAMES H. KIMBALL, Observer.

[Dated: Weather Bureau, Marine Center, New York, N. Y., Oct. 22, 1915.]

Violent storms occurring in the tropical waters of the Pacific Ocean adjacent to the North American Continent are so infrequent that in the preparatory discussion of a large number of observations gathered from that section none in the past five years indicates sufficient storm development to warrant tracing on the Pilot Charts of the United States Hydrographic Office. True, there have been in recent times a few disturbances that have had their inception somewhat to the east of the Hawaiian Islands, whence they swept northwestward, recurving near Japan and afterwards following the usual storm track leading to Alaska.

Well to the east of the Hawaiian Islands lies the region of el Cordonazo de San Francisco,¹ the fanciful name given by the Spaniards to the violent winds that occur on the west coast of Mexico, one in every seven or eight

years, toward the close of the rainy season; that is, about the time of St. Francis's Day, October 4. These storms attain hurricane force, and the observations that follow seem to furnish measurements of one of them.

While the storm experienced by the *Calliope* does not appear to have had sufficient strength to insure its passage westward to the region of storm inception lying near the Hawaiian Islands, still the suggestion is inevitable that future observations may show that a storm track crosses the Pacific from Mexico to Japan.

Extract from meteorological log of steamship *Calliope*, Capt. Chas. E. Topp, Honolulu to Panama, September 4-5, 1915.

- Sept. 4. 2 P. M. Freshening wind from north and backing to NNW.; barometer, 29.90 inches; deep NE. swell.
6 P. M. Strong northerly wind; rising sea; squally.
8 P. M. Fresh NNE. gale; squalls increasing in force and more frequent; heavy rain; barometer, 29.70 inches.
11 P. M. Whole gale from NNE., heavy sea and fierce squalls; barometer 29.50 inches.
Midnight. No change in weather.
- Sept. 5. 2 A. M. Wind suddenly fell to almost a calm and sea falling rapidly; heavy frequent lightning from the south.
2 to 3 A. M. Light wind gradually hauling from NNE. through east to south.
3:15 A. M. Wind blowing from the south a whole gale; sea rose very quickly from that quarter; also very heavy rain squalls. When wind shifted the barometer started to rise almost as rapidly as it had fallen. Wind blew steadily from S. to SSW., and the weather gradually moderated so that I was able to keep away on my course at 6 P. M. Previous to this was hove to and going half speed. During the early hours of the morning of the 5th had tarpaulins ripped off some of the hatches.—Chas. E. Topp.

On the 5th, at 2 A. M. (lat. $15^{\circ} 40'$ N. and long. $109^{\circ} 40'$ W.), with the wind NNE. and force 10 the barometer fell to its lowest reading for the storm, viz, 29.30 inches. Shortly afterwards the wind fell suddenly to the calm as mentioned in the second paragraph of the report.

From the above report it appears that a well-formed vortex of moderate violence prevailed on September 4-5, 1915, about 500 miles south of the most southerly point of Lower California and slightly nearer in a northeasterly direction to Colima, Mexico. The storm, when observed by Capt. Topp, passed close to the position of his ship and was traveling from southeast to northwest.

Unfortunately there were but few readings of the barometer taken, but their number is sufficient to show a moderate though uniform gradient of a vortex having a large diameter at its lowest level.

¹ See this REVIEW, November, 1895, 28: 425.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest

and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, September, 1915.

Section.	Temperature.						Precipitation.							
	Section average. Departure from the normal.		Monthly extremes.				Section average. Departure from the normal.		Greatest monthly.		Least monthly.			
			Station.		Station.				Station.	Amount.	Station.	Amount.		
			Highest.	Date.	Lowest.	Date.								
° F.	° F.	° F.		° F.		Ins.	Ins.	Ins.		Ins.				
Alabama.....	76.6	+1.5	2 stations.....	102	11†	Hamilton.....	40	22	4.43	+1.19	Citronelle.....	8.25	Decatur.....	0.92
Arizona.....	72.7	-1.2	3 stations.....	110	1†	Alpine.....	20	27	0.65	-0.47	Bine.....	3.14	5 stations.....	0.00
Arkansas.....	74.9	+1.3	Booneville.....	100	19	Swain.....	34	22	1.43	-1.92	Pond.....	4.79	Junction.....	T.
California.....	66.2	-2.3	Blythe.....	112	22	Bridgeport.....	16	12	0.06	-0.43	Lordsburg.....	1.00	129 stations.....	0.00
Colorado.....	57.1	-0.6	Holly.....	98	19	Hermit.....	15	14	1.93	+0.43	Columbine.....	7.12	Two Buttes Reser- voir.....	0.08
Florida.....	80.9	+1.8	3 stations.....	101	10†	2 stations.....	58	2†	4.99	-2.00	Newport.....	10.70	Plant City.....	0.97
Georgia.....	76.8	+2.0	4 stations.....	102	12	2 stations.....	41	23	2.63	-1.06	Waynesboro.....	8.41	Hawkinsville.....	0.05
Hawaii (August).....	75.5		Mahukona, Hawaii.....	98	21	Volcano Observa- tory, Hawaii.....	54	26†	2.88		Kumalia Ditch, Kauai.....	12.05	4 stations.....	0.00
Idaho.....	55.2	-1.2	Guffey.....	97	2†	2 stations.....	12	14†	1.29	+0.28	Geneva.....	3.22	Emmett.....	T.
Illinois.....	68.6	+1.9	Golconda.....	97	18	Dakota.....	34	21	4.19	+0.78	Griggsville.....	8.89	Sparta.....	1.09
Indiana.....	68.4	+1.0	2 stations.....	98	11	2 stations.....	33	22	3.64	+0.64	Vevay.....	6.37	Forest Reserve.....	1.47
Iowa.....	63.7	+0.3	3 stations.....	91	8†	Rock Rapids.....	30	21	6.03	+2.67	Marshalltown.....	12.45	Forest City.....	2.88
Kansas.....	69.2	0.0	2 stations.....	100	10†	2 stations.....	32	21	4.83	+2.01	Moran.....	17.93	Hill City.....	0.36
Kentucky.....	70.7	+0.1	Earlington.....	99	13	Weeksbury.....	32	23	3.32	+0.62	Alpha.....	10.15	Louisa.....	1.31
Louisiana.....	79.0	+1.3	Angola.....	105	12	Robeline.....	45	6	3.77	-0.87	Franklinton.....	10.28	Sugartown.....	C.00
Maryland-Delaware.....	69.4	+1.7	Millsboro, Del.....	99	11	2 stations.....	31	23†	2.06	-1.06	State Sanatorium, Md.....	5.19	Milford, Del.....	0.43
Michigan.....	61.4	+1.4	St. Joseph.....	94	14	Humboldt.....	20	29	5.01	+2.04	Hart.....	9.17	Escanaba.....	1.88
Minnesota.....	58.1	-0.1	Hallock.....	93	2	Roseau.....	27	15	2.85	-0.21	Caledonia.....	5.96	Two Harbors.....	0.72
Mississippi.....	77.3	+1.7	5 stations.....	102	11†	2 stations.....	43	22	4.19	+0.70	Columbia.....	11.09	Malone.....	0.65
Missouri.....	70.6	+1.5	Rolla.....	98	14	Ironton.....	34	22	5.25	+1.51	Lockwood.....	12.24	Oakfield.....	0.71
Montana.....	51.2	-4.3	Spring Brook.....	101	5	Bowen.....	15	20	2.22	+0.73	St. Marys Lake.....	5.66	Penwells Ranch.....	0.70
Nebraska.....	62.8	-0.9	Beaver City.....	99	7	Albion.....	26	21	3.60	+1.45	Madison.....	8.54	Orleans.....	0.74
Nevada.....	60.7	-0.8	Logan.....	104	22	Potts.....	19	14†	0.48	+0.20	Jack Creek.....	2.40	2 stations.....	0.00
New England.....	63.4	+3.4	Nashua, N. H.....	96	15†	Madison, Me.....	25	27	1.79	-1.79	Van Buren, Me.....	4.75	Newton, N. H.....	0.20
New Jersey.....	68.5	+2.8	Elizabeth.....	97	9	Charlottesville.....	30	23	2.08	-1.86	Boonton.....	4.46	Imlaystown.....	0.55
New Mexico.....	63.5	-1.1	Artesia.....	103	7†	Senorito (near).....	21	14	2.24	+0.42	Plainview (near).....	7.65	Rodeo.....	T.
New York.....	63.9	+3.1	West Berne.....	95	15	Indian Lake.....	24	28	3.03	-0.25	Skaneateles.....	9.99	Chazy.....	T.
North Carolina.....	72.4	+1.8	4 stations.....	99	10†	Mount Mitchell.....	28	23	3.98	-0.46	Mount Mitchell.....	14.84	Elizabeth City.....	0.75
North Dakota.....	54.6	-1.8	Minot.....	104	1	McKinney.....	23	13	2.40	+0.78	Hannah.....	5.03	Grand Rapids.....	1.27
Ohio.....	67.0	+1.0	Hamilton.....	96	16	Hiram.....	27	29	4.51	+1.85	Philo (2).....	7.58	Green Hill.....	2.23
Oklahoma.....	73.9	+0.2	Erick.....	102	11	Bartlesville.....	38	21	4.55	+1.82	Pawhuska.....	16.18	Heavener.....	1.00
Oregon.....	58.4	+0.3	Culver.....	100	9	Whitaker.....	13	28	0.52	-0.95	Government Camp.....	2.99	3 stations.....	0.00
Pennsylvania.....	66.5	+2.3	Clearfield.....	96	13	3 stations.....	25	29†	2.56	-0.70	Hamburg.....	6.96	Philadelphia (b).....	0.45
Porto Rico.....	79.4	+0.5	Arecibo.....	101	3	2 stations.....	55	4†	8.12	+0.03	Rio Grande(El Verde).....	32.51	Hae Potala.....	0.80
South Carolina.....	75.9	+1.6	Blackville.....	102	11	2 stations.....	43	22†	2.83	-1.60	Kingstree.....	7.06	Darlington.....	0.42
South Dakota.....	58.7	-1.8	2 stations.....	102	1	Pollock.....	23	21	2.59	+1.01	Oelrichs.....	7.16	Redig.....	0.99
Tennessee.....	72.8	+2.1	McMinnville.....	100	13	Mountain City.....	35	23	3.61	+0.36	Erasmus.....	7.37	Bolivar.....	0.27
Texas.....	77.8	+0.5	Quanah.....	106	10	Dalhart.....	41	28†	3.17	+0.41	Junction.....	11.44	Teague.....	T.
Utah.....	58.3	-1.0	Midvale.....	97	1	Ibapah.....	16	15	1.70	+0.65	Silver Lake.....	7.94	Lemay.....	0.34
Virginia.....	69.9	+2.0	Callville.....	97	11	Burkes Garden.....	33	24	2.56	-0.78	Burkes Garden.....	6.33	Wachapreague.....	0.36
Washington.....	58.5	+0.3	Mottinger.....	98	4	2 stations.....	23	13	0.77	-1.04	Cedar Lake.....	4.30	5 stations.....	0.00
West Virginia.....	67.6	+1.3	Romney.....	100	13	2 stations.....	31	23†	3.84	+1.19	Nuttallburg.....	7.18	Piedmont.....	2.00
Wisconsin.....	59.9	+0.1	Osceola.....	93	5	Neillsville (2).....	25	22†	5.53	+2.37	Dodgeville.....	11.88	Hayward (2).....	1.62
Wyoming.....	51.4	-1.4	Fort Laramie.....	99	1	Daniel.....	11	22	2.98	+1.82	Sheridan Creek.....	5.83	Laramie.....	0.89

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations, making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes).....	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches).....	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case the record is broken at the end of each 50 minutes, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high area; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., seventy-fifth meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873-1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly

temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13-16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900-1901, volume 2, Table 27, pages 140-164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction, $t_0 - t$, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind direction, and storm tracks over the North Atlantic Ocean, for the corresponding month of last year.

[Charts XLIII-112 to 114 are figures illustrating the New Orleans hurricane of Sept. 29-30, 1915.]

TABLE I.—Climatological data for United States Weather Bureau stations, September, 1915.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Precipitation.			Wind.					Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.		
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + min. + 2.	Departure from normal.	Maximum.	Date.	Mean minimum.	Date.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Maximum velocity.									
																				Miles per hour.	Direction.	Date.							
New England.																													
Eastport.....	76	67	85	29.89	29.97	-0.06	57.0 + 1.8	80	11	64	38	27	50	26	51	47	76	1.21	-1.8	7	6,899	s.	43	s.	26	11	6	13	5.7
Greenville.....	1,070	6																											
Portland, Me.....	103	82	117	29.92	30.03	-0.11	61.4 + 1.8	89	17	70	40	28	53	28	56	51	74	0.62	-2.6	3	6,726	s.	50	nw.	27	18	6	6	3.8
Concord.....	288	70	79	29.75	30.06	-0.00	63.4 + 4.3	92	15	74	39	23	52	36				1.21	-2.0	5	3,812	nw.	29	nw.	26	20	4	6	3.5
Burlington.....	404	11	48	29.62	30.05	-0.01	62.6 + 3.7	92	18	73	34	30	52	31				0.97	-2.4	9	7,352	s.	50	nw.	26	11	13	6	4.8
Northfield.....	876	12	60	29.13	30.07	-0.01	59.4 + 4.8	89	15	71	30	30	48	41	54	52	84	1.36	-1.4	10	5,059	s.	39	sw.	26	8	12	10	5.7
Boston.....	125	115	188	29.91	30.05	-0.02	66.8 + 4.1	94	15	74	44	28	59	33	60	58	82	0.85	-1.9	4	10,243	sw.	42	w.	26	14	6	10	4.4
Nantucket.....	12	14	90	30.04	30.05	-0.03	65.0 + 2.2	81	14	71	46	28	60	17	62	60	86	1.35	-1.6	5	11,336	sw.	59	sw.	26	15	12	3	4.0
Block Island.....	26	11	46	30.03	30.06	-0.02	65.4 + 1.3	83	10	71	46	28	60	17	62	60	86	1.35	-1.6	5	11,336	sw.	60	nw.	26	15	5	9	4.2
Narragansett Pier.....	160	215	251	29.88	30.05	-0.02	64.7 + 1.9	89	10	74	35	28	56	30				1.77		7									
Providence.....	159	122	140	29.89	30.07	-0.02	66.2 + 3.0	92	16	75	41	28	57	27	60	56	75	0.88	-2.3	6	8,222	nw.	62	nw.	26	18	7	3	3.5
Hartford.....	106	117	155	29.95	30.06	-0.01	67.4 + 5.7	92	16	77	42	28	58	30	60	57	76	1.29	-2.2	7	4,860	s.	37	nw.	26	12	10	7	4.7
New Haven.....	106	117	155	29.95	30.06	-0.01	68.0 + 4.1	91	16	77	43	28	59	28	62	58	78	1.35	-2.4	6	6,031	nw.	34	sw.	26	16	7	7	4.2
Middle Atlantic States.																													
Albany.....	97	102	115	29.96	30.06	-0.11	66.9 + 4.6	92	15	76	41	30	58	29	60	57	77	2.17	-1.0	9	4,926	s.	33	nw.	26	15	12	3	3.7
Binghamton.....	871	10	69	29.17	30.09	-0.02	65.8 + 5.8	91	15	76	35	23	55	33				1.85	-0.9	10	2,904	nw.	25	nw.	26	13	7	10	5.0
New York.....	314	414	454	29.74	30.07	-0.01	69.0 + 2.5	90	9	77	44	28	61	23	61	57	71	2.52	-1.1	6	10,756	nw.	72	nw.	26	11	13	6	4.8
Harrisburg.....	374	94	104	29.70	30.10	-0.02	68.8 + 3.9	91	15	78	42	29	60	27	62	59	76	3.10	-0.2	8	3,718	s.	28	nw.	26	11	13	7	4.3
Philadelphia.....	117	123	190	29.97	30.09	-0.01	71.4 + 4.0	92	9	80	47	28	63	22	64	61	75	0.46	-2.9	6	6,205	sw.	34	nw.	26	12	10	8	4.4
Reading.....	325	81	98	29.75	30.10	-0.01	69.4 + 3.6	92	14	79	42	23	59	32	62	58	76	2.26	-1.4	8	3,983	sw.	25	nw.	26	11	12	8	5.1
Scranton.....	805	111	119	29.24	30.10	-0.03	85.8 + 3.6	92	15	76	36	23	55	33	60	56	77	2.91	0.0	11	3,716	sw.	32	sw.	26	11	11	8	5.0
Atlantic City.....	52	37	48	30.03	30.09	-0.02	69.6 + 2.0	92	9	76	41	28	63	29	64	62	80	0.60	-2.4	2	5,282	sw.	24	s.	26	11	18	3	4.2
Cape May.....	18	13	49	30.09	30.11	-0.04	70.0 + 1.0	92	9	77	45	23	63	23				0.70	-2.3	4	5,509	nw.	28	nw.	26	11	10	3	3.3
Sandy Hook.....	22	10	57	30.05	30.07	-0.02	69.5 + 2.8	91	9	79	43	28	63	22	64	62	82	1.02	-3.0	4	5,509	nw.	28	nw.	26	15	10	5	4.4
Trenton.....	190	159	183	29.87	30.07	-0.01	69.4 + 2.8	91	9	79	43	28	63	22	64	62	82	1.02	-3.0	4	5,509	nw.	28	nw.	26	15	10	5	4.4
Baltimore.....	123	100	113	29.97	30.10	-0.02	71.5 + 2.9	93	9	80	46	29	63	25	64	60	71	2.30	-1.6	7	4,382	n.	28	n.	26	11	11	8	4.7
Washington.....	112	62	85	29.97	30.09	-0.01	71.0 + 2.9	94	13	81	43	30	61	31	63	60	76	1.39	-2.2	7	3,415	s.	28	n.	26	11	15	5	3.9
Lynchburg.....	681	153	188	29.36	30.09	-0.01	70.6 + 2.2	93	12	81	41	23	60	32	64	61	81	3.26	-0.4	7	3,577	n.	26	w.	26	14	7	9	4.9
Norfolk.....	91	170	205	30.00	30.10	-0.04	74.2 + 2.5	92	12	81	57	22	68	23	67	63	75	1.76	-2.3	7	7,524	ne.	36	nw.	26	14	9	7	4.5
Richmond.....	144	11	52	29.95	30.10	-0.03	72.4 + 1.6	93	13	82	45	23	63	28	65	62	78	1.99	-1.4	9	4,285	ne.	32	sw.	26	16	5	9	4.4
Wytheville.....	2,293	40	47	27.77	30.10	-0.03	65.6 + 2.0	88	11	76	35	23	55	33	60	58	87	5.73	+2.4	14	2,422	e.	19	nw.	26	16	5	7	4.8
South Atlantic States.																													
Asheville.....	2,255	70	84	27.79	30.10	-0.03	67.4 + 2.4	86	10	78	40	23	57	33	61	59	83	4.09	+1.0	11	4,379	s.	44	e.	30	12	14	4	4.3
Charlotte.....	773	153	161	29.26	30.08	-0.01	73.2 + 2.5	93	10	82	48	23	64	27	65	62	74	2.37	-0.8	6	6,281	ne.	31	sw.	26	10	16	4	4.3
Hatteras.....	11	12	50	30.06	30.07	-0.01	77.1 + 2.4	91	10	82	60	28	72	17	72	69	80	1.26	-4.1	9	8,043	ne.	41	ne.	20	10	16	4	5.1
Manteo.....	12	4	46																										
Raleigh.....	376	103	110	29.69	30.08	-0.01	73.8 + 3.2	94	11	83	50	23	65	30	66	63	76	2.54	-0.8	11	4,517	ne.	24	w.	26	12	10	8	4.6
Wilmington.....	78	81	91	29.99	30.07	-0.02	76.0 + 2.9	96	10	84	54	23	68	22	70	68	84	2.71	-2.6	10	4,931	ne.	28	ne.	22	12	12	6	4.7
Charleston.....	48	11	92	30.00	30.06	-0.02	79.2 + 3.0	95	10	85	63	23	73	20	73	71	80	2.07	-3.4	9	7,357	e.	29	e.	22	15	11	5	3.8
Columbia.....	351	41	57	29.70	30.07	-0.02	76.8 + 3.1	98	11	87	53	23	67	29	68	65	75	0.96	-2.5	6	4,372	ne.	26	ne.	22	18	7	5	3.8
Augusta.....	180	89	97	29.87	30.06	-0.01	77.2 + 2.8	97	11	86	55	23	68	26	70	67	78	4.91	+1.2	6	3,609	ne.	24	n.	24	13	9	8	4.8
Savannah.....	65	150	194	29.98	30.04	-0.01	78.5 + 3.1	96	11	86	60	23	71	23	72	71	83	4.49	-1.1	9	7,481	ne.	39	se.	15	12	10	8	4.8
Jacksonville.....	43	209	245	29.97	30.02	-0.02	79.8 + 2.5	94	9	86	67	23	73	21	73	71	82	8.41	+0.4	13	8,224	ne.	41	s.	30	15	8	7	4.2
Florida Peninsula.																													
Key West.....	22	10	64	29.90	29.92	-0.02	82.4 + 0.1	90	4	88	72	15	77	16	77	74	78	4.96	-3.0										
Miami.....	25	71	79	29.93	29.96	-0.01	81.0 + 0.5	88	4	86	71	15	76	15	76	74	77	7.32	+0.5	20	7,651	e.	38	s.	3	14	7	9	5.0
Sand Key.....	23	39	72	29.87	29.90	-0.04	81.1 + 0.5	88	4	84	70	15	74	12	77	75	80	5.27	-4.1	15	7,458	e.	32	e.	2	13	6	9	5.8
Tampa.....	35	79	96	29.94	29.97	-0.00	81.7 + 3.4	93	11	90	70	15	74	20	74	72	77	2.08	-5.3	12	5,304	ne.	38	ne.	15	12	12	6	4.8
East Gulf States.																													
Atlanta.....	1,174	190	216	28.85	30.07	-0.02	74.9 + 2.8	92	12	84	51	22	66	25	66	62	70	3.53	0.0	7	6,130	e.	40	se.	4	11	13	6	4.9
Macon.....	370	78	87	29.64	30.04	-0.01	77.5 + 4.6	98	10	88	54	23	67	28	69	65	73	1.35	-2.0	5	3,937	ne.	32	s.	4	14	10	5	4.5
Thomasville.....	273	8	57	29.72	30.01	-0.09	80.3 + 3.5	99	9	91	63	23	69	31	71	69	82	4.41	+0.2	11	3,794	ne.	24	s.	4	5	20	10	5.5
Pensacola.....	56	140	182	29.93	29.99	-0.00	79.6 + 1.7.																						

TABLE I.—Climatological data for United States Weather Bureau stations, September, 1915—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.		
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. + 2.	Departure from normal.	Maximum.	Date.	Mean minimum.	Date.	Mean maximum.	Date.	Mean minimum.	Date.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity.								
																									Miles per hour.							Direction.	Date.
Ohio Valley and Tennessee.	ft.	ft.	ft.	in.	in.	in.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	in.	in.	Miles.								0-10	4.5		
Chattanooga	762	189	213	29.27	30.07	+0.01	73.4	+2.2	92	12	83	48	23	64	26	66	64	78	6.91	+3.7	9	3,716	w.	27	ne.	4	14	12	4	4.2			
Knoxville	996	93	100	29.03	30.06	-.00	72.8	+3.4	91	14	83	48	23	63	29	65	62	76	4.04	+1.2	7	2,768	ne.	18	sw.	5	14	6	10	4.7			
Memphis	399	76	97	29.63	30.05	-.02	76.0	+3.2	91	13	84	49	22	68	22	65	65	76	0.55	+2.5	4	4,739	sw.	36	sw.	20	22	3	5	3.0			
Nashville	546	168	191	29.48	30.06	-.00	73.9	+2.3	94	13	84	47	23	64	28	66	62	74	4.63	+1.0	8	5,045	ne.	37	ne.	30	16	10	4	3.5			
Lexington	989	193	230	29.02	30.08	-.01	69.5	+1.6	91	13	78	44	22	61	28	66	62	74	3.71	+1.3	9	8,348	sw.	39	nw.	18	15	10	5	4.0			
Louisville	525	219	255	29.50	30.08	-.02	71.7	+1.8	92	13	81	46	22	62	31	63	60	73	2.34	+0.3	7	7,152	s.	38	s.	18	14	8	8	4.6			
Evansville	431	72	82	29.58	30.04	-.02	72.6	+2.9	92	13	82	46	22	63	28	65	62	77	2.98	+0.3	7	4,609	s.	30	s.	14	16	11	3	4.1			
Indianapolis	822	194	230	29.19	30.07	-.01	68.1	+1.4	91	14	77	43	29	59	28	61	58	77	4.17	+1.1	11	7,430	s.	48	w.	14	11	9	10	5.3			
Terre Haute	575	96	129	29.43	30.04	-.02	69.6	+1.9	91	14	79	44	22	60	30	62	59	77	5.19	+1.5	12	6,061	s.	43	s.	15	7	15	8	5.8			
Cincinnati	628	11	51	29.40	30.07	-.00	68.4	+0.6	90	13	78	42	29	59	29	62	59	79	5.65	+3.3	10	4,364	s.	26	sw.	26	11	9	10	5.1			
Columbus	824	173	222	29.22	30.09	-.02	68.0	+2.1	90	13	78	41	29	59	27	61	59	79	4.43	+1.9	11	6,582	s.	32	sw.	26	17	8	5	3.6			
Dayton	899	181	216	29.12	30.06	-.02	68.0	+0.6	89	13	77	42	29	59	31	62	59	80	5.44	+2.9	10	6,205	ne.	34	sw.	7	13	10	7	4.9			
Pittsburgh	842	353	410	29.20	30.09	-.01	68.8	+2.7	90	14	78	43	28	60	26	60	56	68	1.71	+0.8	9	6,850	sw.	48	w.	18	12	11	7	4.7			
Elkins	1,940	41	50	28.08	30.12	+.04	65.8	+3.9	89	14	78	37	23	53	38	58	56	87	3.04	+0.2	13	1,983	w.	18	se.	5	7	14	9	5.7			
Parkersburg	638	77	84	29.45	30.10	+.02	69.4	+3.3	92	13	80	43	23	59	29	62	60	82	4.19	+1.5	14	2,888	se.	23	se.	5	17	6	7	3.9			
Lower Lake region.							65.3	+2.2											78	3.69	+0.9									4.9			
Buffalo	767	247	280	29.25	30.07	+.01	64.6	+1.7	87	14	72	39	27	57	25	60	57	78	1.35	+1.8	8	9,606	sw.	72	sw.	26	13	7	10	4.8			
Canton	448	10	61	29.58	30.03	-.00	61.4	+2.1	88	14	72	30	30	51	34	59	50	78	1.32	+1.5	10	6,402	sw.	46	w.	26	14	11	5	3.7			
Oswego	335	76	91	29.69	30.06	-.00	64.4	+1.7	90	14	72	42	30	57	26	59	50	78	3.44	+0.6	7	6,081	s.	35	nw.	26	10	11	9	3.4			
Rochester	523	97	113	29.52	30.09	+.03	65.4	+3.5	92	14	75	39	29	59	28	58	55	74	2.26	+0.1	7	4,984	sw.	36	w.	26	13	9	8	4.6			
Syracuse	597	97	113	29.45	30.10	+.03	64.7	+3.1	89	14	73	38	28	56	30	59	56	79	5.11	+2.3	13	6,983	s.	48	nw.	26	8	11	11	5.6			
Erle	714	130	166	29.31	30.07	+.01	66.4	+2.5	91	14	74	41	28	58	26	61	58	78	4.19	+0.7	12	8,462	s.	48	sw.	26	7	17	6	5.0			
Cleveland	762	190	201	29.27	30.08	-.02	67.0	+2.7	89	13	74	43	29	60	23	60	57	74	4.23	+1.0	12	8,801	s.	41	w.	26	11	8	11	4.8			
Sandusky	629	62	103	29.39	30.07	+.01	67.3	+2.0	91	14	75	45	22	60	25	61	58	77	5.11	+2.4	10	7,534	sw.	36	nw.	10	11	8	11	5.0			
Toledo	628	208	243	29.40	30.08	-.02	66.3	+2.2	89	14	74	38	26	58	25	61	58	80	5.45	+3.1	9	6,732	sw.	52	w.	10	14	9	7	4.5			
Fort Wayne	856	113	124	29.16	30.08	-.02	65.8	+0.3	89	14	75	37	29	57	30	61	59	84	3.70	+1.5	13	6,035	sw.	37	w.	10	10	10	10	5.6			
Detroit	730	218	245	29.28	30.07	+.01	65.0	+1.9	89	14	73	37	29	57	28	60	57	80	4.47	+2.0	11	7,492	sw.	42	nw.	10	9	13	8	4.8			
Upper Lake region.							60.7	+1.5											82	4.42	+1.1									5.7			
Alpena	609	13	92	29.40	30.07	+.04	58.9	+1.6	89	14	67	33	30	50	30	54	52	82	2.37	+1.1	15	7,410	nw.	40	nw.	26	6	15	9	5.9			
Escanaba	612	54	60	29.37	30.03	+.02	57.6	+0.7	78	4	65	34	29	50	24	53	51	82	1.88	+1.7	13	6,273	s.	39	n.	26	11	6	13	5.5			
Grand Haven	632	54	62	29.37	30.04	-.01	62.2	+1.1	83	4	70	37	29	54	26	58	55	83	8.05	+4.9	13	7,267	s.	38	nw.	20	11	6	13	5.3			
Grand Rapids	707	70	87	29.29	30.06	+.01	64.4	+2.0	90	14	74	35	29	55	31	58	55	78	8.11	+5.0	14	3,920	e.	26	nw.	12	8	14	14	5.8			
Houghton	684	62	72	29.27	30.00	-.00	57.2	+1.1	85	5	65	35	29	49	30	51	57	80	4.30	+0.8	14	5,838	w.	37	nw.	20	3	14	13	6.5			
Lansing	878	11	62	29.11	30.04	-.00	63.2	+1.9	89	4	74	33	29	53	37	58	56	88	6.55	+3.9	11	3,553	sw.	19	nw.	26	9	13	8	5.0			
Ludington	637	60	66	29.35	30.04	-.01	60.2	+1.1	83	4	68	35	28	52	25	56	54	84	8.14	+5.0	15	6,801	s.	37	s.	23	8	11	11	5.6			
Marquette	734	77	111	29.21	30.05	+.05	57.6	+0.8	83	1	64	33	29	51	26	52	49	78	3.68	+0.2	13	6,992	e.	48	w.	14	7	9	14	6.3			
Port Huron	638	70	120	29.38	30.06	-.00	63.2	+2.3	87	14	71	35	29	55	26	59	56	82	2.40	+0.3	11	7,242	sw.	34	nw.	26	9	17	4	4.7			
Saginaw	641	48	82	29.36	30.06	-.00	62.8	+1.1	89	14	72	33	29	53	30	58	56	85	4.55	+1.4	13	5,785	s.	28	s.	14	8	7	15	6.1			
Sault Ste. Marie	614	11	61	29.36	30.06	+.04	56.0	+2.0	84	14	66	30	28	46	32	51	49	84	4.15	+0.7	15	5,105	e.	40	nw.	20	7	10	13	6.2			
Chicago	823	140	310	29.16	30.04	-.00	67.2	+2.0	90	14	73	46	21	61	22	62	58	76	3.53	+0.5	14	8,436	ne.	41	sw.	10	10	8	12	5.9			
Green Bay	617	109	144	29.36	30.02	-.00	61.2	+2.1	84	6	70	39	29	53	30	55	53	81	5.10	+2.0	13	7,268	s.	54	sw.	8	2	16	12	6.8			
Milwaukee	681	119	133	29.31	30.04	+.01	64.2	+2.7	87	13	71	43	21	57	28	58	55	78	4.93	+2.0	14	6,722	sw.	34	ne.	10	9	10	11	5.8			
Duluth	1,133																																

TABLE I.—Climatological data for United States Weather Bureau stations, September, 1915—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Precipitation.			Wind.							Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. +2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of dew point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity.						Clear days.	Partly cloudy days.	Cloudy days.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>%</i>	<i>In.</i>	<i>In.</i>		<i>Miles.</i>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.															
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.		
Ablene, Tex.	14-15			1.86																			
Albany, N. Y.	21			1.00																			
Alpena, Mich.	16			1.07																			
Amarillo, Tex.	25	1:45 p.m.	6:10 p.m.	0.98	3:22 p.m.	3:43 p.m.	0.36	0.06	0.19	0.32	0.45	0.48											
Anniston, Ala.	4-5	7:13 a.m.	6:44 a.m.	2.44	6:36 p.m.	7:32 p.m.	1.34	.07	.16	.24	.27	.37	0.49	0.70	0.72								
Asheville, N. C.	21			0.55																			
Atlanta, Ga.	13	4:23 p.m.	5:10 p.m.	0.70	4:39 p.m.	4:54 p.m.	.03	.16	.49	.67													
Atlantic City, N. J.	19			0.36																			
Augusta, Ga.	4-20	9:35 p.m.	D.N. p.m.	1.47	10:46 p.m.	11:24 p.m.	.07	.08	.19	.33	.60	.97	1.19	1.28	1.37								
	20	10:15 a.m.	1:00 p.m.	0.81	11:13 a.m.	11:56 a.m.	.07	.14	.25	.31	.32	.39	.51	.55	.64	0.68							
Baker, Oreg.	12			0.05																			
Baltimore, Md.	18	9:45 p.m.	11:55 p.m.	0.78	10:04 p.m.	10:34 p.m.	.01	.18	.28	.32	.38	.47	.55										
Bentonville, Ark.	17	11:40 a.m.	1:15 p.m.	1.27	11:48 a.m.	12:13 p.m.	.01	.23	.58	.79	1.11	1.22											
Binghamton, N. Y.	17	1:25 p.m.	3:45 p.m.	0.60	1:53 p.m.	2:13 p.m.	.01	.17	.28	.42	.53												
Birmingham, Ala.	19	3:47 p.m.	5:53 p.m.	1.29	4:33 p.m.	5:34 p.m.	.10	.15	.21	.33	.44	.52	.64	.79	.86	.89	0.94	1.16	1.19				
	29-11	6:20 p.m.	D.N. a.m.	2.81	10:38 a.m.	11:17 a.m.	2.00	.07	.14	.24	.29	.35	.48	.54	.62								
Bismarck, N. Dak.	13			0.44																			
Block Island, R. I.	1			0.66																			
Boise, Idaho.	1			0.24																			
Boston, Mass.	21			0.59																			
Buffalo, N. Y.	6			0.39																			
Burlington, Vt.	21			0.53																			
Cairo, Ill.	20	9:15 a.m.	1:20 p.m.	1.68	11:32 a.m.	11:44 a.m.	.42	.21	.34	.40													
					12:15 p.m.	12:36 p.m.	.93	.14	.24	.51	.64	.68											
Canton, N. Y.	8			0.25																			
Charles City, Iowa.	19-20			0.90																			
Charleston, S. C.	21			0.58																			
Charlotte, N. C.	4	5:35 p.m.	6:28 p.m.	0.43	5:37 p.m.	5:53 p.m.	.01	.11	.26	.37	.41												
Chattanooga, Tenn.	4-5	4:14 p.m.	4:22 a.m.	2.15	11:51 p.m.	12:45 a.m.	1.04	.07	.24	.43	.50	.56	.63	.67	.71	.81	.86	.90					
	30	3:06 a.m.	8:48 p.m.	4.07	3:25 p.m.	4:04 p.m.	2.56	.10	.20	.28	.37	.56	.64	.70	.78</								

1 Oct. 1.

TABLE II.—Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during September, 1915, at all stations furnished with self-registering gages—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Kalispell, Mont.	8-9			0.54	4:22 p.m.	4:40 p.m.	0.04	0.12	0.28	0.55	0.66							0.21			
Kansas City, Mo.	8	4:05 p.m.	6:20 p.m.	0.81	4:22 p.m.	4:40 p.m.	0.04	0.12	0.28	0.55	0.66										
Keokuk, Iowa.	10	1:03 p.m.	1:43 p.m.	0.52	1:24 p.m.	1:37 p.m.	T.	.31	.47	.51											
	11	7:03 p.m.	8:45 p.m.	1.84	7:03 p.m.	8:23 p.m.	.00	.10	.23	.39	.49	0.57	0.65	0.79	1.06	1.17	1.27	1.47	1.79		
Key West, Fla.	3	3:45 a.m.	6:40 a.m.	0.68	3:50 a.m.	4:26 a.m.	.01	.05	.23	.30	.33	.40	.45	.58	.61						
	15	4:25 p.m.	D. N. p.m.	1.16	5:59 p.m.	6:54 p.m.	.08	.10	.22	.48	.58	.69	.71	.74	.89	.91	.93	1.03			
Knoxville, Tenn.	20	7:42 p.m.	8:35 p.m.	0.94	7:49 p.m.	8:26 p.m.	.01	.11	.34	.50	.53	.56	.76	.89	.93						
La Crosse, Wis.	12	7:15 p.m.	D. N. p.m.	1.00	8:38 p.m.	8:57 p.m.	.21	.06	.21	.39	.50										
	12	D. N. a.m.	8:05 p.m.	1.36	6:56 a.m.	7:06 a.m.	.06	.18	.34												
Lander, Wyo.	2-3			1.62	5:05 p.m.	5:12 p.m.	.87	.34	.46												
	12	5:30 a.m.	8:10 a.m.	0.73	5:48 a.m.	6:15 a.m.	.02	.08	.15	.20	.29	.52	.56								
Lansing, Mich.	12			0.33																	
Lewiston, Idaho.	12			1.49																	
Lexington, Ky.	30			1.64	7:03 p.m.	7:25 p.m.	.01	.13	.28	.47	.60	.76									
Lincoln, Nebr.	17	6:45 p.m.	10:10 p.m.	0.63	8:06 p.m.	8:24 p.m.	.89	.06	.25	.43	.49										
	28			T.																	
Little Rock, Ark.	10			1.46																	
Los Angeles, Cal.	24			1.33	8:02 p.m.	8:32 p.m.	.40	.13	.14	.30	.49	.75	.89								
Louisville, Ky.	30			1.61	5:04 a.m.	5:36 a.m.	.34	.10	.24	.31	.41	.45	.53	.57							
Ludington, Mich.	8	7:06 p.m.	9:30 p.m.	0.51	9:57 p.m.	10:04 p.m.	.02	.32	.38												
Lynchburg, Va.	15-16	D. N. p.m.	11:10 a.m.	1.38	3:02 p.m.	4:27 p.m.	.05	.08	.13	.23	.46	.75	.95	1.05	1.12	1.16	1.23	1.23	1.66	1.81	
	5	9:45 p.m.	10:50 p.m.	1.64	6:10 p.m.	6:34 p.m.	2.09	.09	.22	.35	.43	.52									
Macon, Ga.	29-11			3.10	10:49 a.m.	11:16 a.m.	.57	.13	.45	.62	.88	1.01	1.03								
	10	8:12 a.m.	11:35 a.m.	2.10	3:02 p.m.	4:27 p.m.	.05	.08	.13	.23	.46	.75	.95	1.05	1.12	1.16	1.23	1.23	1.66	1.81	
Madison, Wis.	12	2:40 p.m.	9:05 p.m.	2.10	6:10 p.m.	6:34 p.m.	2.09	.09	.22	.35	.43	.52									
Marquette, Mich.	12-13	10:30 p.m.	3:00 a.m.	2.10	12:51 a.m.	2:52 a.m.	.15	.24	.34	.41	.44	.46	.48	.51	.56	.58	.60				
	13	12:42 p.m.	4:57 p.m.	0.89	3:14 p.m.	3:26 p.m.	.27	.81	.91	1.06	1.09	1.18	1.20	1.32	1.35	1.40	1.64				
Memphis, Tenn.	17			0.13				1.74	1.80	1.85	1.92	1.94									
Meridian, Miss.	29-30	5:15 p.m.	3:44 p.m.	6.83	10:15 p.m.	1:55 a.m.	1.40	.22	.42	.50											
								.07	.10	.15	.33	.53	.95	1.14	1.18	1.24	1.29				
Miami, Fla.	15	2:33 p.m.	3:20 p.m.	0.48	3:44 a.m.	4:14 a.m.	5.50	1.34	1.38	1.40	1.51	1.63	1.94	2.03	2.05	2.13	2.22				
Milwaukee, Wis.	10	10:25 a.m.	2:30 p.m.	0.98	10:30 a.m.	11:00 a.m.	0.02	2.29	2.36	2.43	2.48	2.54	2.57	2.58	2.60	2.62	2.65				
Minneapolis, Minn.	14			1.29				2.71	2.76	2.81	2.89	2.95	2.99	3.11	3.18	3.25	3.31				
Mobile, Ala.	29-30			3.12				3.48	3.60	3.66	3.71										
Modena, Utah.	3			1.27				.07	.21	.42	.45	.51	.65								
Montgomery, Ala.	4	5:20 a.m.	8:00 p.m.	3.50	1:54 p.m.	2:38 p.m.	1.22	.05	.11	.16	.22	.31	.36	.46	.60	.65					
Moorhead, Minn.	11			0.39				.18	.35	.41											
Mount Tamalpais, Cal.	†			0.37																	
Nantucket, Mass.	21			0.54	2:45 p.m.	2:59 p.m.	.01	.17	.35	.47											
Nashville, Tenn.	28	2:43 p.m.	3:35 p.m.	0.81	11:46 a.m.	11:55 a.m.	.31	.28	.45												
New Haven, Conn.	21	7:00 a.m.	12:25 p.m.	0.81				.10	.24	.35	.45	.56	.65	.74	.88	1.11	1.25				
New Orleans, La.	29	2:35 a.m.	11:30 p.m.	8.20	10:50 a.m.	1:26 p.m.	2.02	1.40	1.58	1.69	1.82	1.89	2.04	2.15	2.24	2.30	2.35				
								2.40	2.48	2.52	2.54	2.59	2.67	2.81	2.97	3.09	3.16				
New York, N. Y.	17	4:48 p.m.	5:11 p.m.	0.46	4:34 p.m.	5:10 p.m.	6.80	3.27	3.31												
	19	1:58 p.m.	2:35 p.m.	0.50	4:51 p.m.	5:06 p.m.	T.	.06	.17	.30	.42	.66	.90	1.16	1.21						
Norfolk, Va.	19			0.34	2:01 p.m.	2:09 p.m.	.01	.22	.38	.45											
Northfield, Vt.	7			0.26				.30	.42												
North Head, Wash.	5	6:48 p.m.	8:55 p.m.	0.49	8:08 p.m.	8:23 p.m.	.08	.20	.29	.37											
North Platte, Nebr.	14-15			1.14																	
Oklahoma, Okla.	17			0.52																	
Omaha, Nebr.	17			1.13																	
Oswego, N. Y.	8	2:00 p.m.	2:50 p.m.	1.33	2:13 p.m.	2:33 p.m.	T.	.18	.72	1.05	1.12										
Palestine, Tex.	15			0.33																	
Parkersburg, W. Va.	18	9:50 p.m.	11:04 p.m.	1.16	10:03 p.m.	10:36 p.m.	.04	.17	.20	.31	.60	.71	1.01	1.08							
Pensacola, Fla.	21	1:35 p.m.	3:15 p.m.	0.81	2:05 p.m.	2:33 p.m.	.08	.16	.27	.40	.51	.59	.65								
Peoria, Ill.	10	6:49 p.m.	11:00 p.m.	0.94	6:49 p.m.	7:09 p.m.	.00	.18	.49	.55	.63										
Philadelphia, Pa.	21			0.18																	
Phoenix, Ariz.	2			0.09																	
Pierre, S. Dak.	12-14			1.11																	
Pittsburgh, Pa.	18			0.56																	
Pocatello, Idaho.	25-26			1.92																	
Point Reyes Light, Cal.	†			0.41																	
Port Huron, Mich.	16			0.24																	
Portland, Me.	13			0.18																	
Portland, Oreg.	10			0.52																	
Providence, R. I.	25	3:37 p.m.	5:10 p.m.	0.98	4:11 p.m.	4:31 p.m.	.01	.44	.80	.90	.95										
Pueblo, Colo.	4	8:07 p.m.	8:38 p.m.	0.44	8:10 p.m.	8:26 p.m.	T.	.18	.37	.43	.44										
Raleigh, N. C.	26			0.87																	
Rapid City, S. Dak.	21	4:10 a.m.	10:15 a.m.	1.09	7:34 a.m.	7:54 a.m.	.35	.29	.43	.51	.62										
Reading, Pa.	†			0.03																	
Red Bluff, Cal.	1			0.63																	
Reno, Nev.	18	6:26 p.m.	7:07 p.m.	0.80	6:34 p.m.	6:47 p.m.	.02	.13	.51	.59											
Richmond, Va.	13			0.35																	

TABLE II.—Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during September, 1915, at all stations furnished with self-registering gages—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.																
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.			
Santa Fe, N. Mex.	3-4			0.74																				
Sault Ste. Marie, Mich.	24-26			1.60																				
Savannah, Ga.	4-5	9:40 p.m.	1:00 a.m.	0.93	12:14 a.m.	12:36 a.m.	0.39	0.08	0.14	0.26	0.48	0.53												
	29-30	8:50 p.m.	7:20 a.m.	1.50	5:28 a.m.	6:09 a.m.	.04	.09	.23	.49	.66	.77	1.07	1.22	1.30	1.35								
Scranton, Pa.	18-19			1.25																				
Seattle, Wash.	8			0.17																				
Sheridan, Wyo.	5	12:30 a.m.	6:55 a.m.	1.16	1:15 a.m.	1:32 a.m.	.19	.11	.27	.38	.45													
Shreveport, La.	20-21	6:30 p.m.	D. N. a.m.	1.61	10:07 p.m.	11:35 p.m.	.15	.14	.22	.23	.24	.29	.34	.39	.48	.53	0.60	.79	1.07	1.21				
Sioux City, Iowa.	12-14			0.83														.37						
Spokane, Wash.	23			0.17														.10						
Springfield, Ill.	14-15	D. N. p.m.	D. N. a.m.	0.80	2:01 a.m.	2:14 a.m.	.17	.22	.40	.44														
Springfield, Mo.	20	D. N. a.m.	8:15 a.m.	0.84	5:45 a.m.	6:10 a.m.	.12	.07	.16	.26	.36	.50												
Syracuse, N. Y.	13	D. N. a.m.	D. N. a.m.	1.49	3:09 a.m.	3:44 a.m.	.29	.17	.30	.44	.56	.66	.70	.78										
Tacoma, Wash.	11-12	9:14 p.m.	D. N. a.m.	0.46	9:59 p.m.	10:18 p.m.	.03	.06	.21	.35	.39													
Tampa, Fla.	6			0.47																				
Tatoosh Island, Wash.	1			0.70														.41						
Taylor, Tex.	15	10:03 a.m.	1:32 p.m.	1.40	11:13 a.m.	11:40 a.m.	.68	.09	.20	.24	.33	.50	.54					.30						
Terre Haute, Ind.	16	3:10 p.m.	3:50 p.m.	0.70	3:10 p.m.	3:23 p.m.	.00	.16	.54	.64														
	17	10:04 a.m.	1:58 p.m.	1.69	11:27 a.m.	12:19 p.m.	.05	.29	.47	.69	.87	.95	.97	1.00	1.01	1.11	1.30	1.41						
Thomasville, Ga.	28	4:10 p.m.	5:35 p.m.	1.01	4:16 p.m.	4:37 p.m.	.01	.08	.35	.76	.93	.97												
Toledo, Ohio.	5	11:45 a.m.	8:20 p.m.	1.07	5:24 p.m.	6:05 p.m.	.63	.07	.13	.23	.39	.45	.52	.62	.67	.70								
Tonopah, Nev.	24			0.24														.24						
Topeka, Kans.	25	4:00 a.m.	6:55 a.m.	0.92	6:14 a.m.	6:39 a.m.	.39	.10	.20	.31	.38	.50												
Valentine, Nebr.	13	12:25 a.m.	1:50 a.m.	0.43	12:42 a.m.	12:53 a.m.	T.	.18	.33	.40														
Vicksburg, Miss.	17			0.43														.41						
Walla Walla, Wash.	11-12			0.67														.17						
Washington, D. C.	6			0.61														.34						
Wichita, Kans.	19-20	10:15 p.m.	D. N. a.m.	0.92	11:42 p.m.	12:16 a.m.	.02	.14	.25	.35	.54	.65	.72	.79										
Williston, N. Dak.	24			0.39														.31						
Wilmington, N. C.	21	3:13 p.m.	4:05 p.m.	0.64	3:16 p.m.	3:36 p.m.	.01	.06	.27	.42	.55													
Winnemucca, Nev.	25			0.87														.30						
Wytheville, Va.	29	7:30 a.m.	10:55 a.m.	1.00	8:24 a.m.	8:51 a.m.	.10	.13	.28	.43	.58	.66	.75	.81										
Yankton, S. Dak.	13-14	9:40 p.m.	2:30 a.m.	0.98	10:45 p.m.	10:58 p.m.	.09	.20	.34	.39														
Yellowstone Park, Wyo.	25-27			0.52														*						

* Self-register not working.

† Record partly estimated.

‡ No precipitation occurred during month.

¹ Oct. 1.

TABLE III.—Data furnished by the Canadian Meteorological Service, September, 1915.

Stations.	Pressure.			Temperature.						Precipitation.		
	Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. + 2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
St. Johns, N. F.	29.68	29.82	-0.15	52.8	-1.2	59.3	46.3	78	34	3.94	+0.23	
Sydney, C. B. I.	29.86	29.90	-.11	57.5	+1.0	66.7	48.3	83	36	1.92	-1.36	
Halifax, N. S.	29.86	29.96	-.08	59.4	+1.8	69.1	49.7	85	33	2.58	-1.13	
Yarmouth, N. S.	29.91	29.98	-.07	57.4	+1.3	64.1	50.7	76	36	1.18	-2.27	
Charlottetown, P. E. I.	29.87	29.91	-.10	58.0	+0.7	65.6	50.4	80	38	3.08	-0.32	
Chatham, N. B.	29.90	29.92	-.08	57.3	+1.9	67.4	47.3	88	32	6.17	+3.46	1.2
Father Point, Que.	29.92	29.94	-.04	50.2	-0.2	57.4	43.1	70	32	4.82	+1.64	2.0
Quebec, Que.	29.68	30.00	-.01	57.0	+1.9	65.5	48.6	84	32	5.28	+1.61	
Montreal, Que.	29.82	30.02	-.02	62.0	+3.6	70.6	53.3	88	39	2.57	-0.73	
Stonecliffe, Ont.	29.48	30.08	+0.05	58.0	+2.3	68.8	47.3	89	30	2.77	-0.51	
Ottawa, Ont.	29.78	30.10	+0.06	60.8	+3.4	70.1	51.5	88	36	3.21	+0.52	
Kingston, Ont.	29.76	30.07	+0.03	62.7	+2.7	71.5	54.0	81	32	1.49	-1.31	
Toronto, Ont.	29.66	30.03	-.03	63.3	+4.3	72.9	53.7	87	31	4.24	+0.99	
White River, Ont.	28.69	30.01	-.03	50.4	+0.1	63.4	37.5	83	20	4.15	+1.38	T.
Port Stanley, Ont.	29.44	30.08	+0.02	61.8	+2.3	70.3	53.3	81	33	2.90	+0.17	
Southampton, Ont.	29.37			60.0	+2.5	69.1	51.0	87	33	3.18	+0.24	
Parry Sound, Ont.	29.36	30.04	+0.01	59.4	+3.4	69.6	49.2	87	28	3.83	+0.16	
Port Arthur, Ont.	29.20	30.01	+0.03	53.3	+1.1	62.2	44.4	84	29	4.13	+0.65	
Winnipeg, Man.	29.12	29.95	+0.01	54.7	+2.2	64.3	45.1	92	32	4.89	+2.86	
Minneapolis, Man.	28.14	29.95	+0.01	49.2	-1.3	59.8	38.6	88	22	2.63	+0.67	
Qu'Appelle, Sask.	27.68	29.92	-.00	47.8	-3.3	57.2	38.3	81	26	4.43	+3.10	4.3
Medicine Hat, Alberta.	27.64	29.91	-.01	54.6	-0.4	65.9	43.3	84	28	2.17	+0.99	1.9
Swift Current, Sask.	27.36	29.92	-.00	49.9	-3.2	61.7	38.2	85	24	1.27	+0.05	3.0
Calgary, Alberta.	26.32	29.84	-.08	48.8	-1.0	62.1	35.6	82	24	2.33	+0.97	1.0
Banff, Alberta.	25.27	29.93	-.00	45.9	+0.1	56.8	35.1	73	18	2.69	+1.02	3.0
Edmonton, Alberta.	27.63	29.92	+0.02	48.1	-1.2	59.5	36.7	77	20	0.97	-0.36	0.4
Prince Albert, Sask.	28.37	29.93	+0.03	45.7	-2.7	53.7	37.7	74	14	1.16	-0.12	T.
Battleford, Sask.	28.23	29.96	+0.06	49.0	-2.8	61.5	36.5	79	14	0.67	-0.58	T.
Kamloops, B. C.	28.73	30.01	+0.04	56.8	-0.6	67.6	45.9	84	36	0.61	-0.24	
Victoria, B. C.	29.75	30.00	-.01	56.5	+1.7	63.5	49.6	73	45	0.80	-1.36	
Barkerville, B. C.												
Hamilton, Bermuda.	29.76	29.92	-.15	75.4	-2.0	80.3	70.5	85	66	16.30	+9.79	

Chart I. Hydrographs of Several Principal Rivers, September, 1915.

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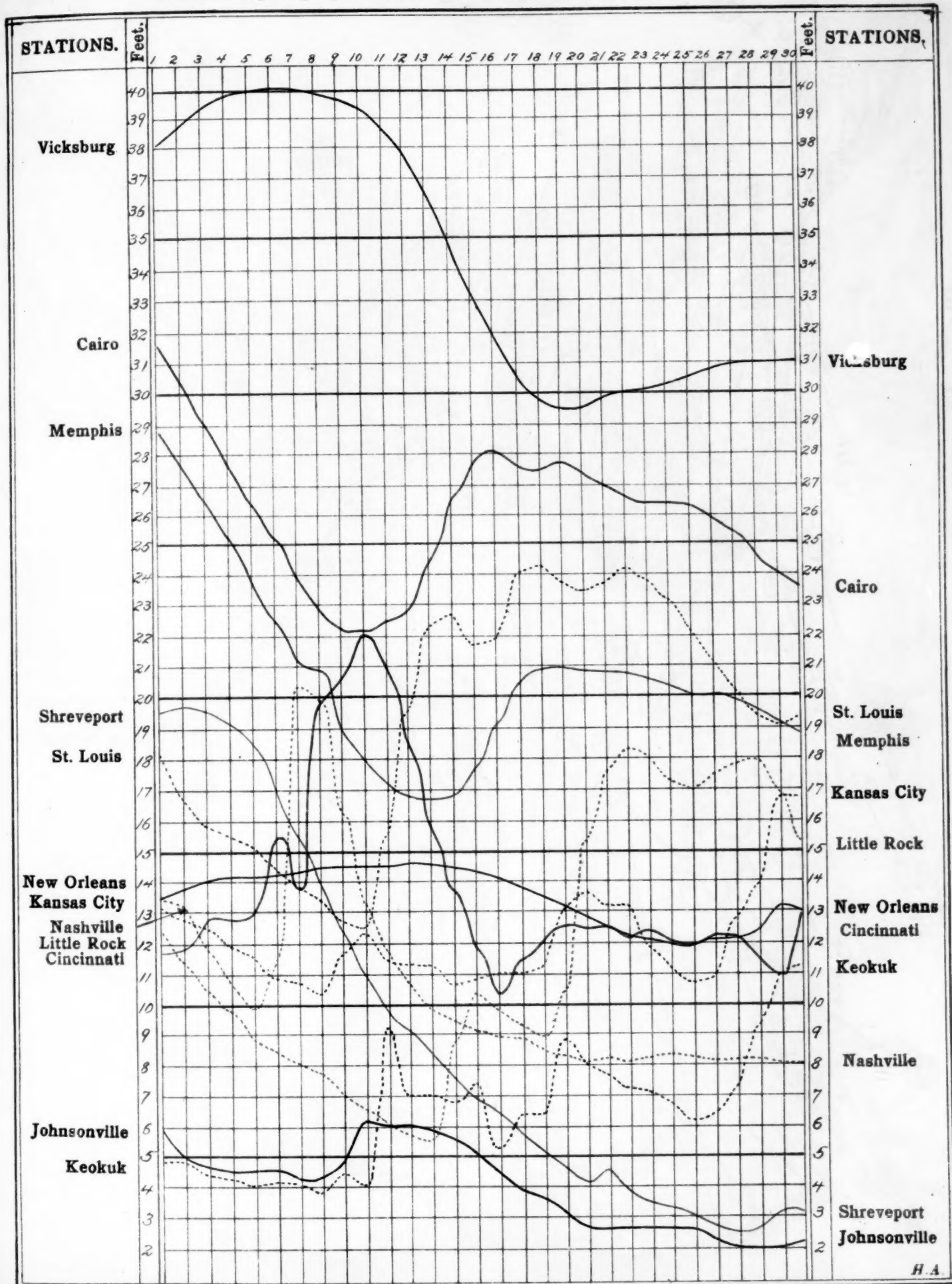


Chart II. Tracks of Centers of High Areas, September, 1915.
(Plotted by R. H. Weightman.)

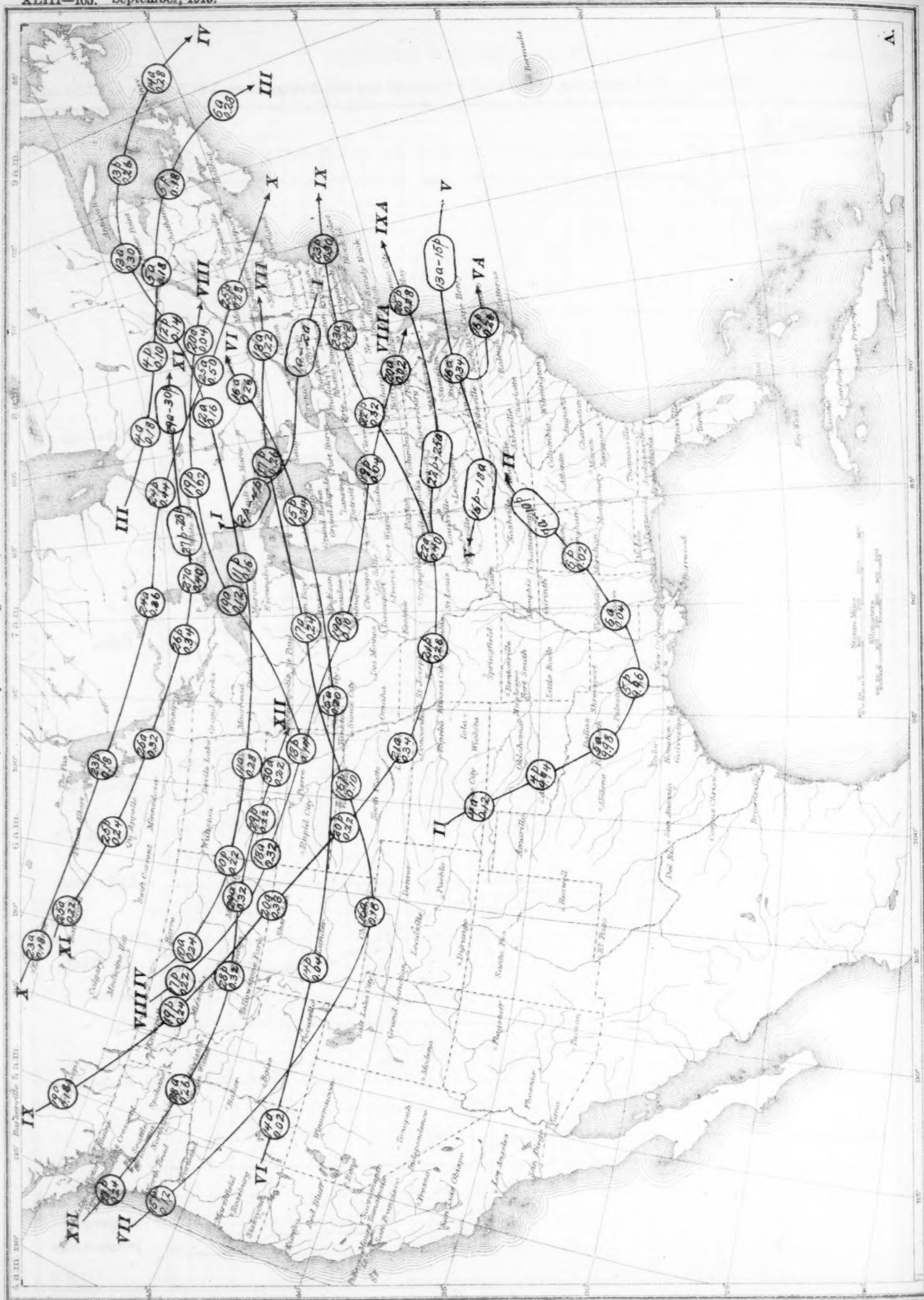


Chart III. Tracks of Centers of Low Areas, September, 1915.
(Plotted by R. H. Weightman.)

Chart III. Tracks of Centers of Low Areas, September, 1915.
(Plotted by R. H. Weightman.)

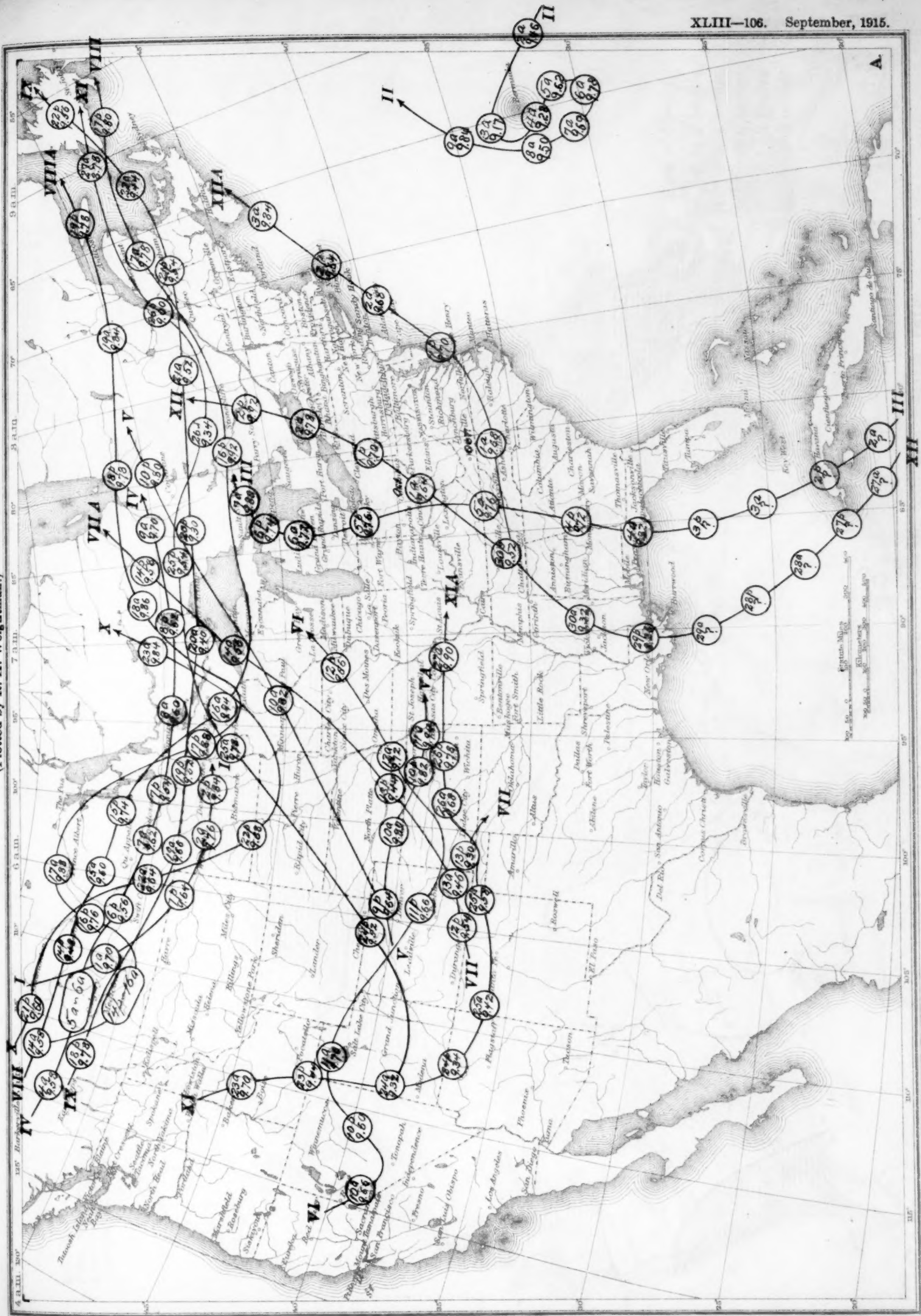


Chart IV. Departure (°F.) of the Mean Temperature from the Normal, September, 1915.

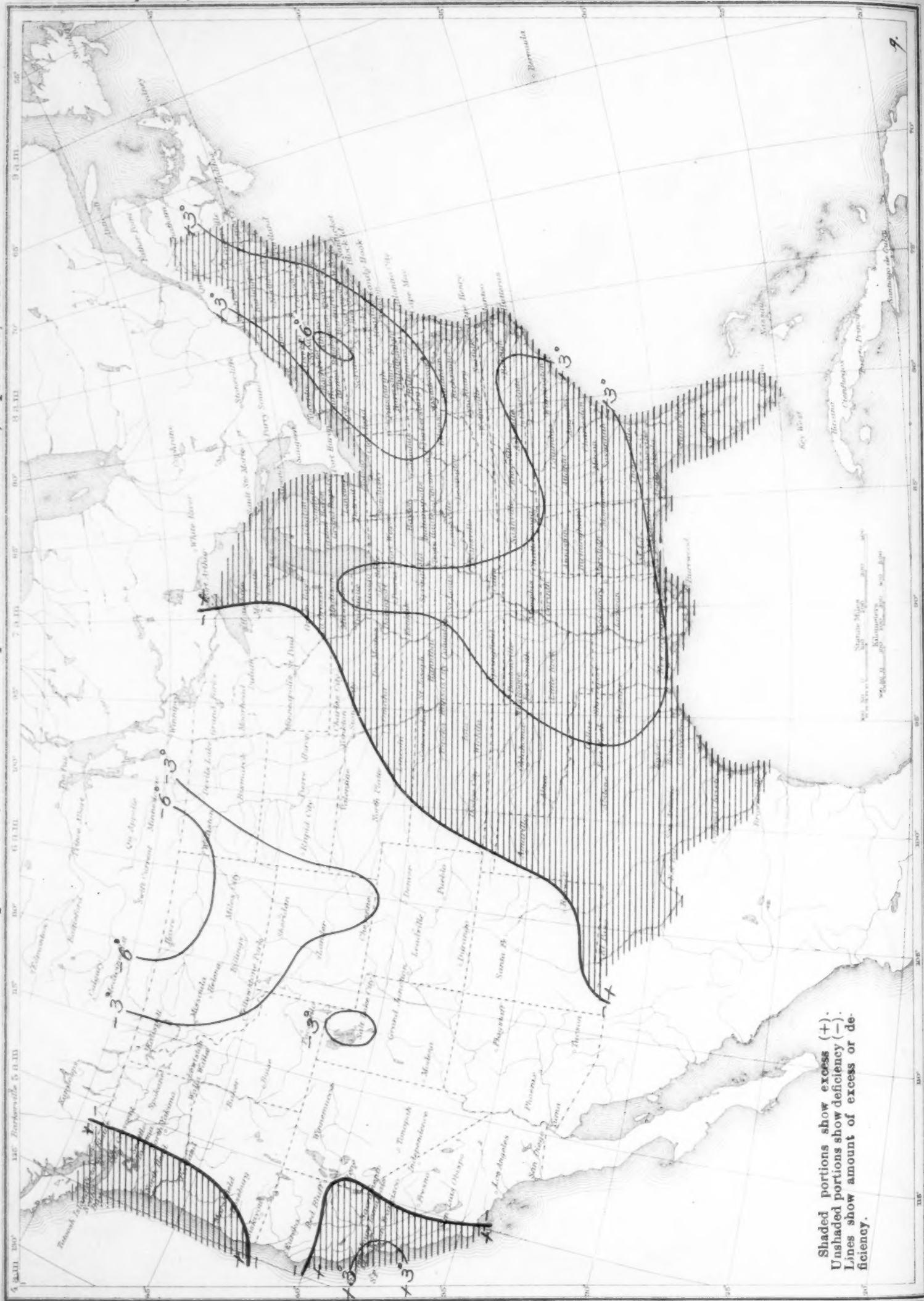


Chart V. Total Precipitation, September, 1915.

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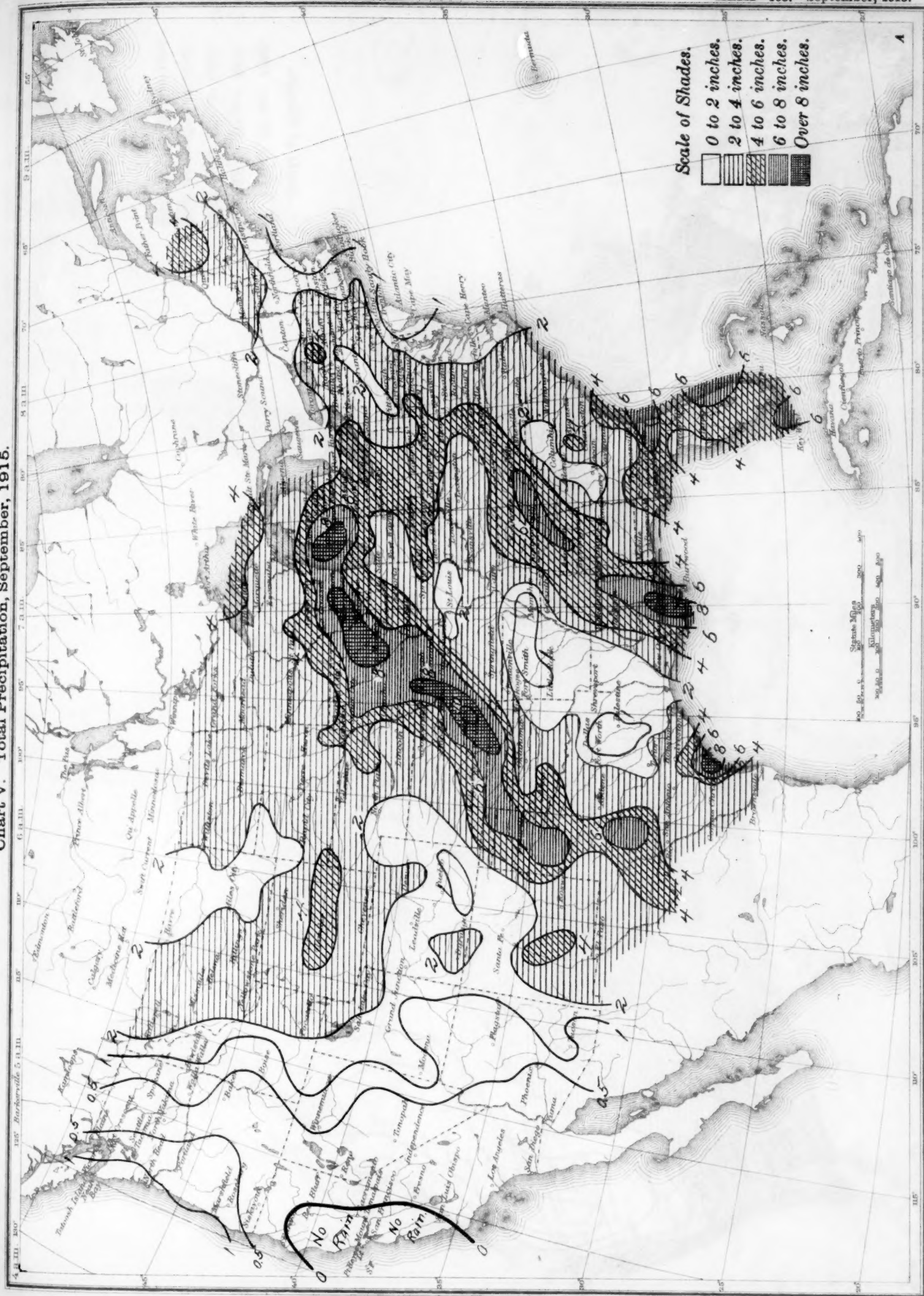


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, September, 1915.

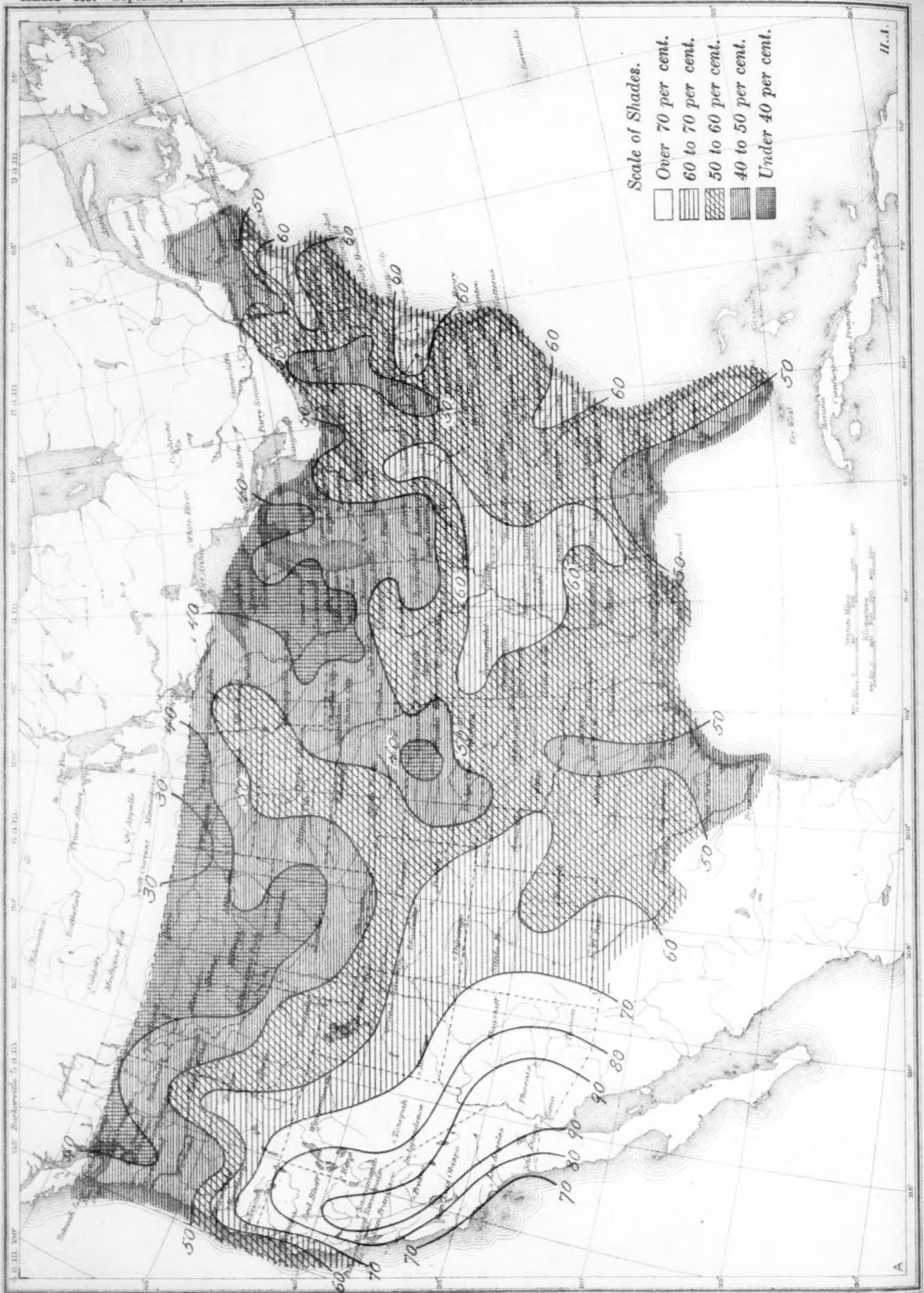


Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, September, 1915.

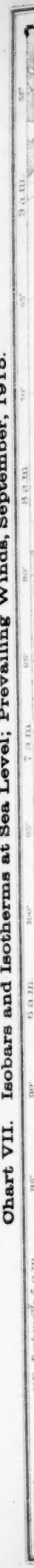


Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, September, 1915.

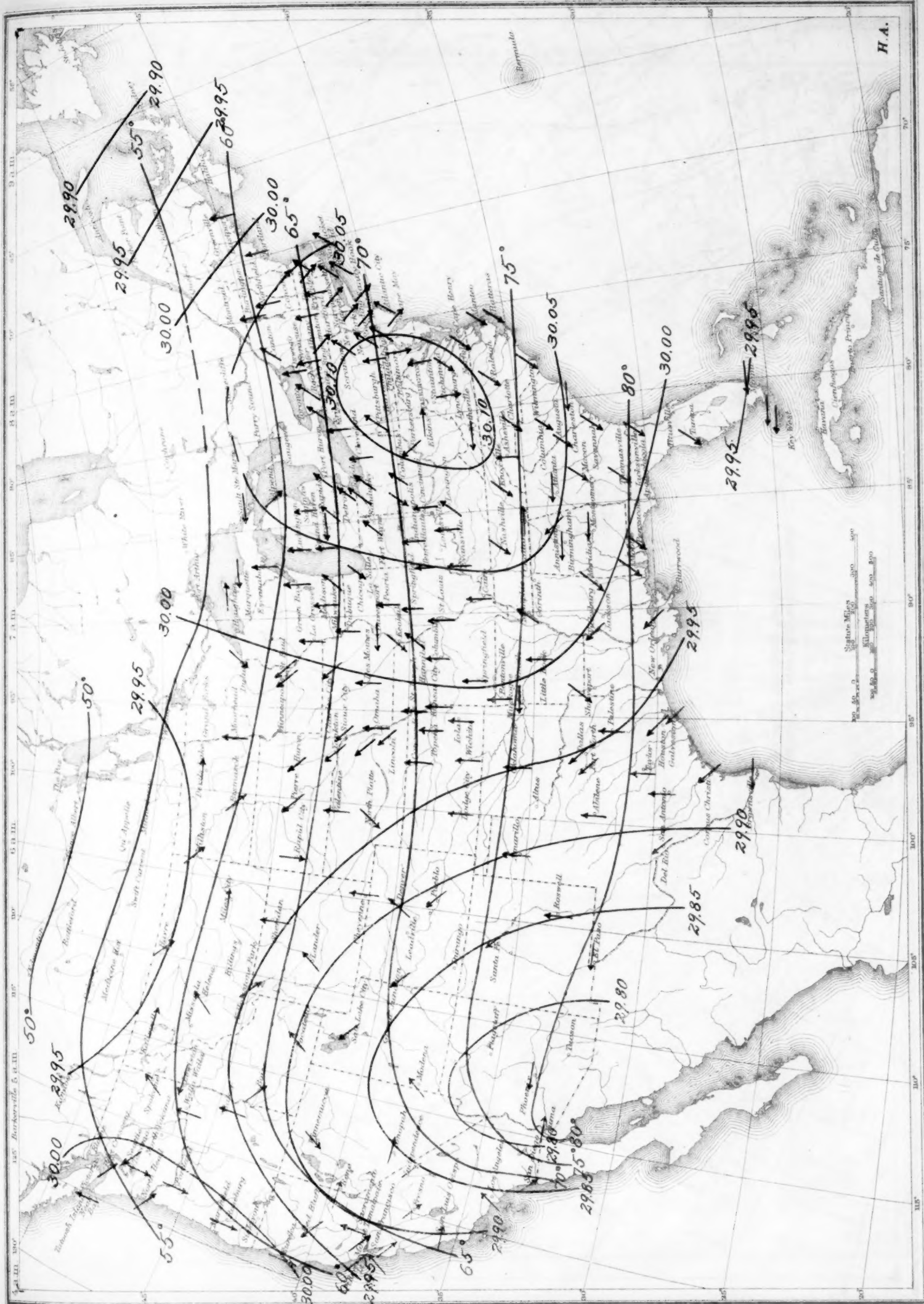
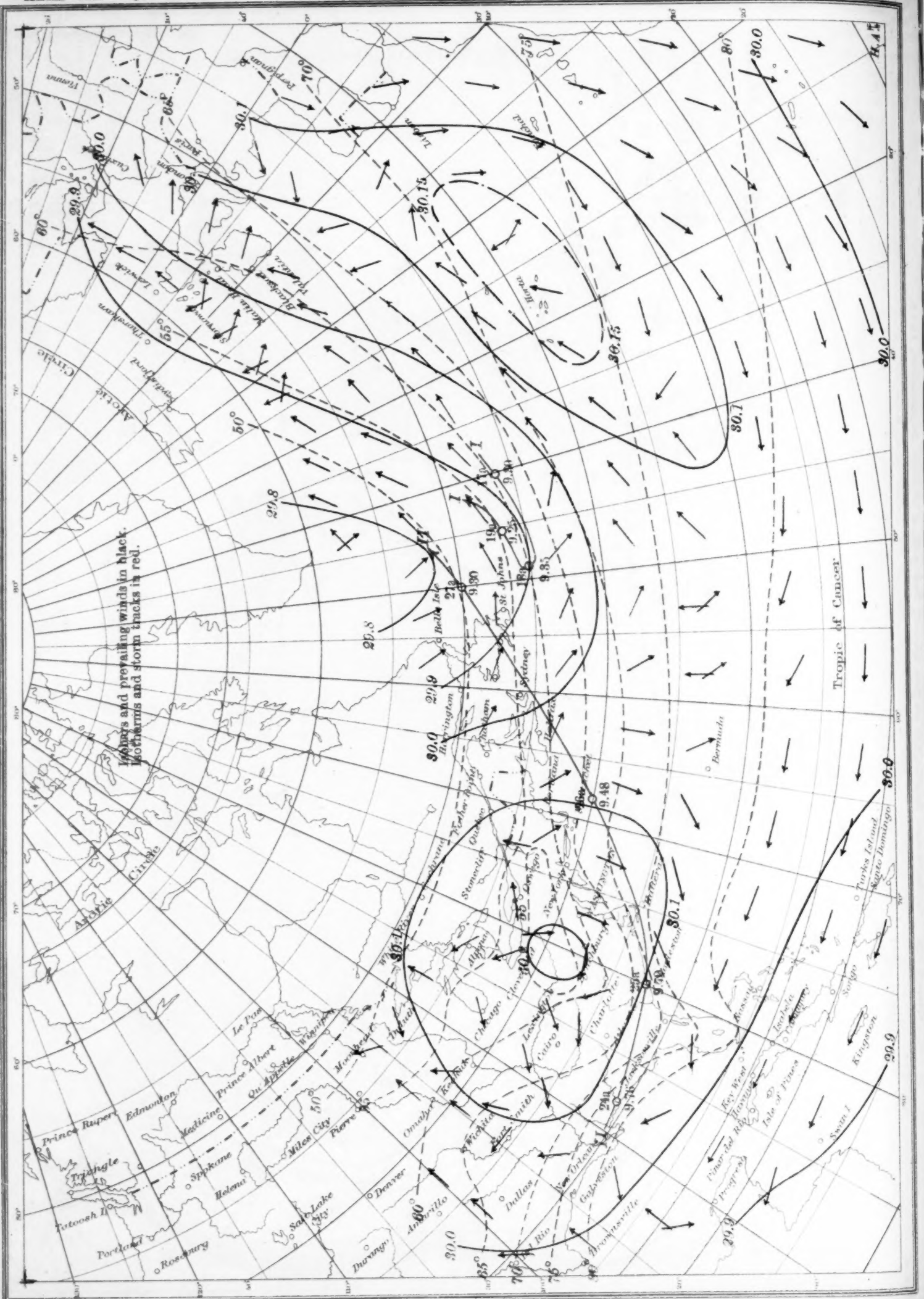
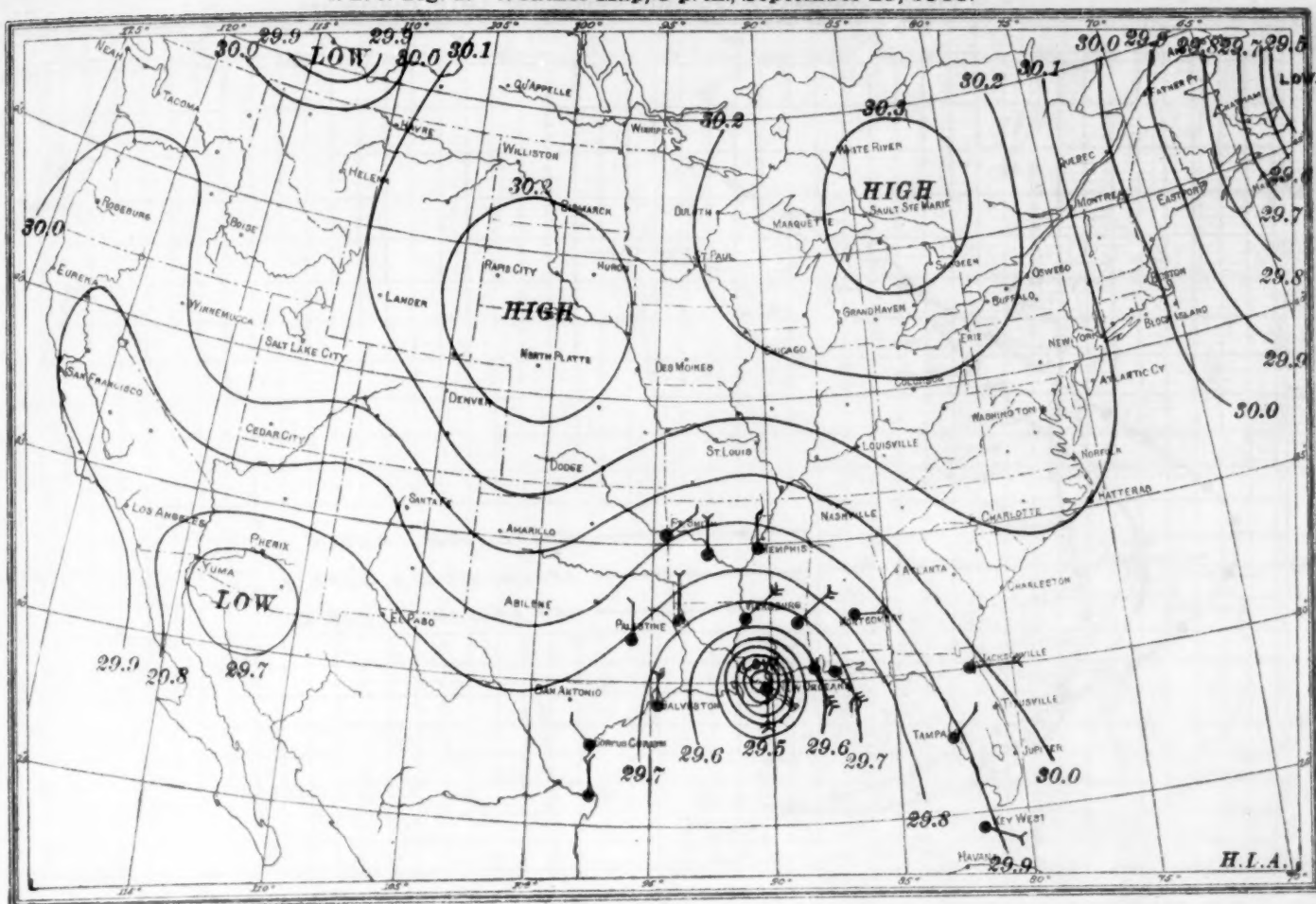


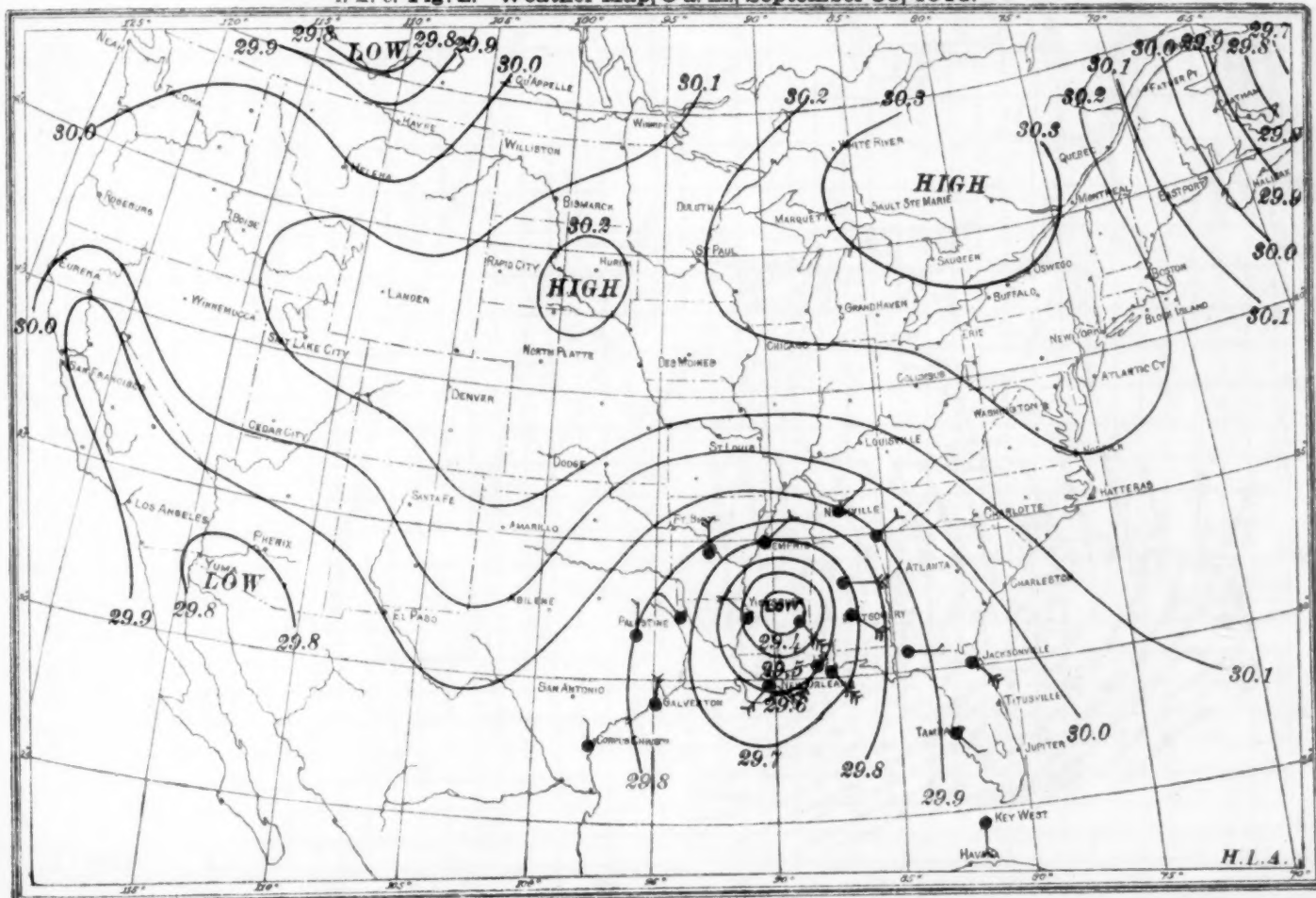
Chart IX. Means of Meteorological Data for North Atlantic Ocean, September, 1914.



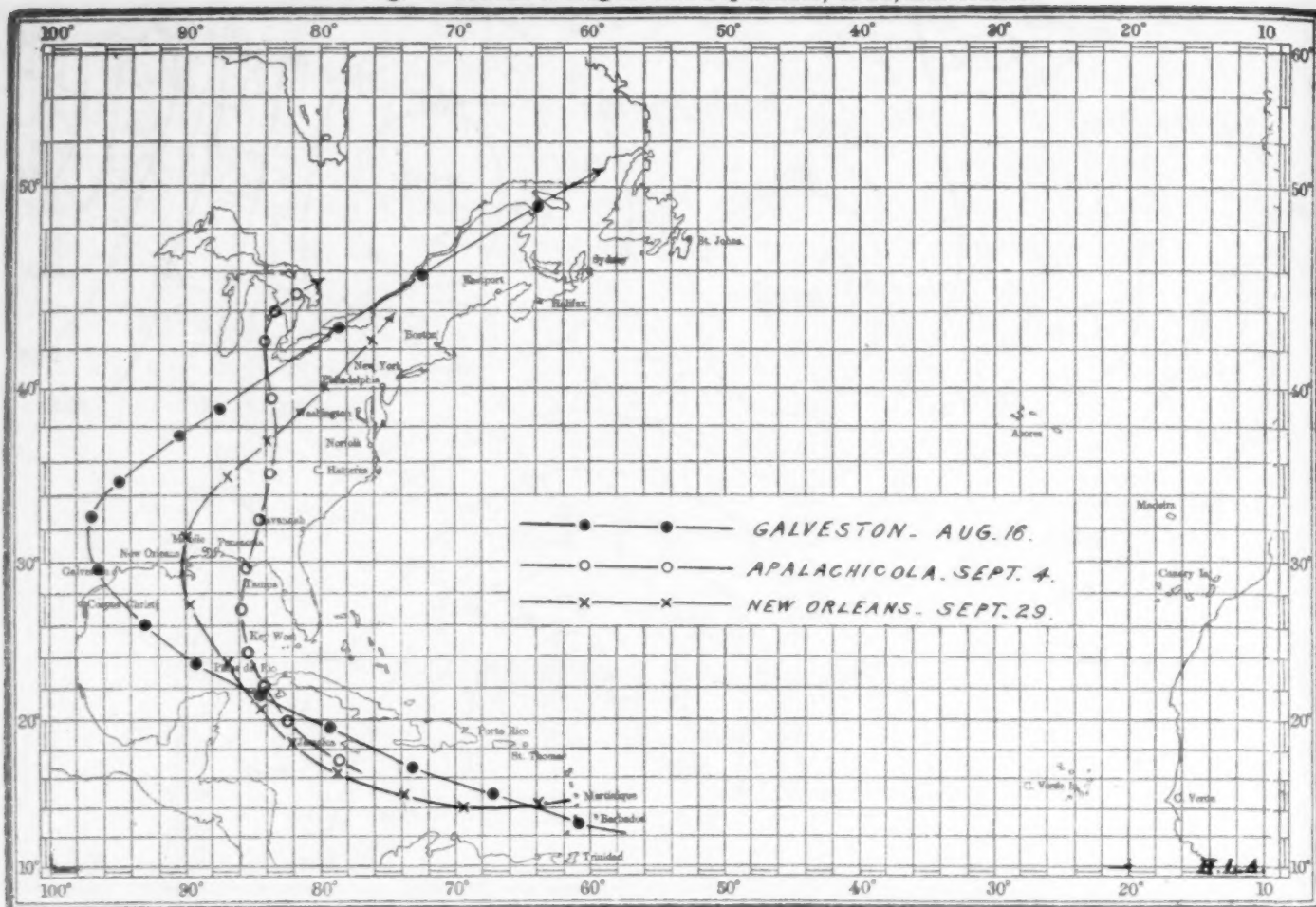
I. M. C. Fig. 1. Weather Map, 8 p. m., September 29, 1915.



I. M. C. Fig. 2. Weather Map, 8 a. m., September 30, 1915.



I. M. C. Fig. 3. Tracks of August and September, 1915, Hurricanes.



I. M. C. Fig. 4. Average 24-Hour Movement of Hurricanes during September.

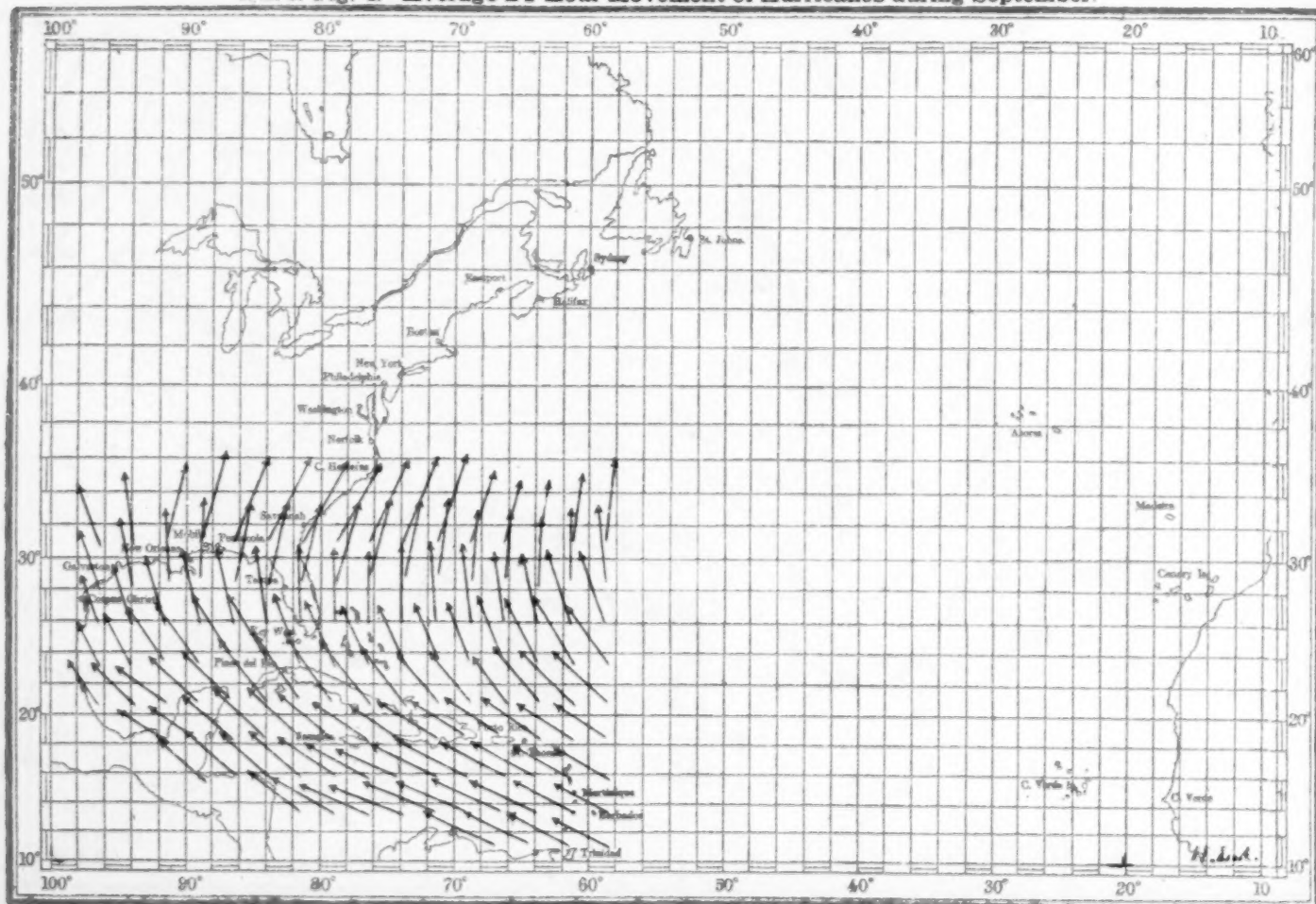


Fig. 5.

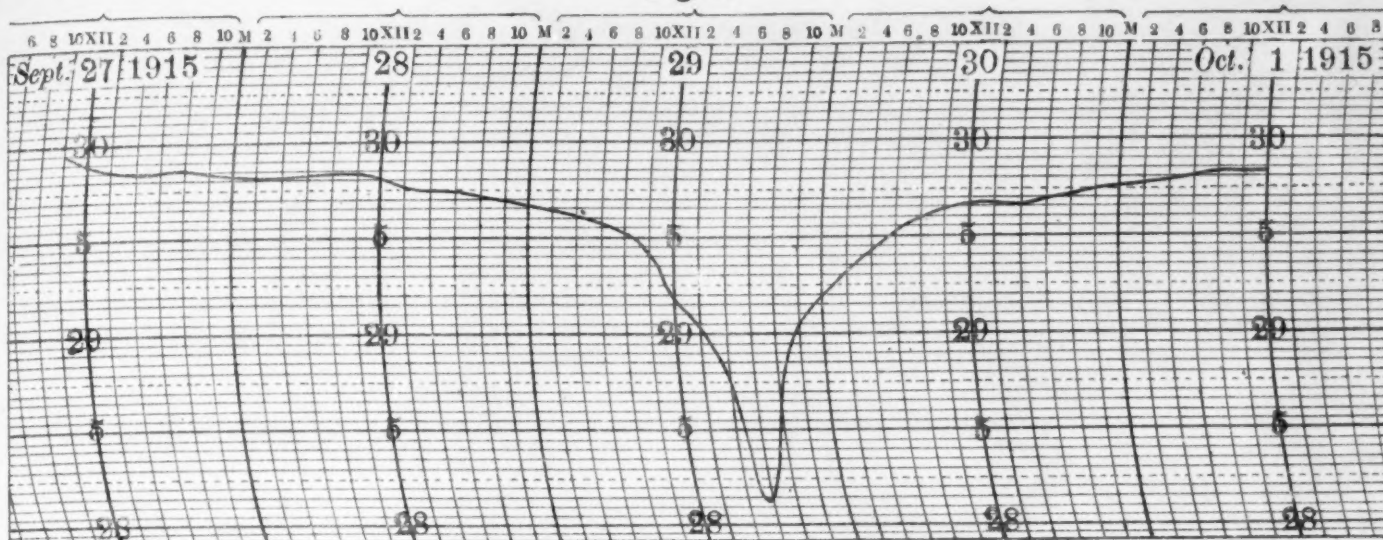


Fig. 6.

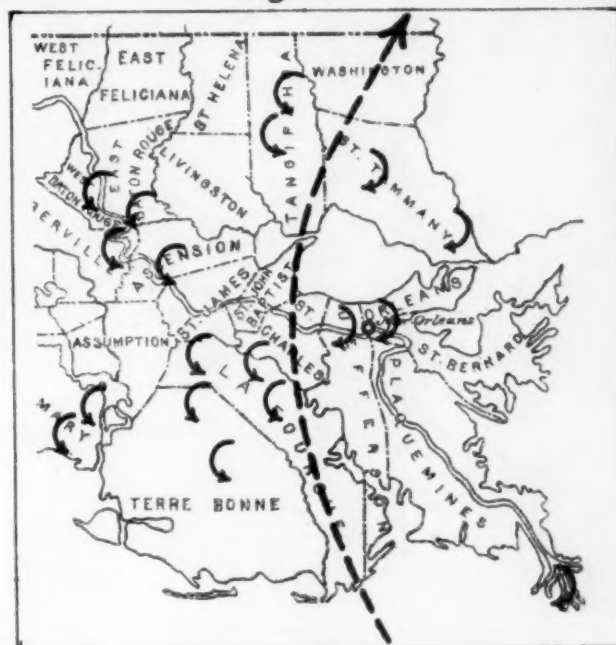
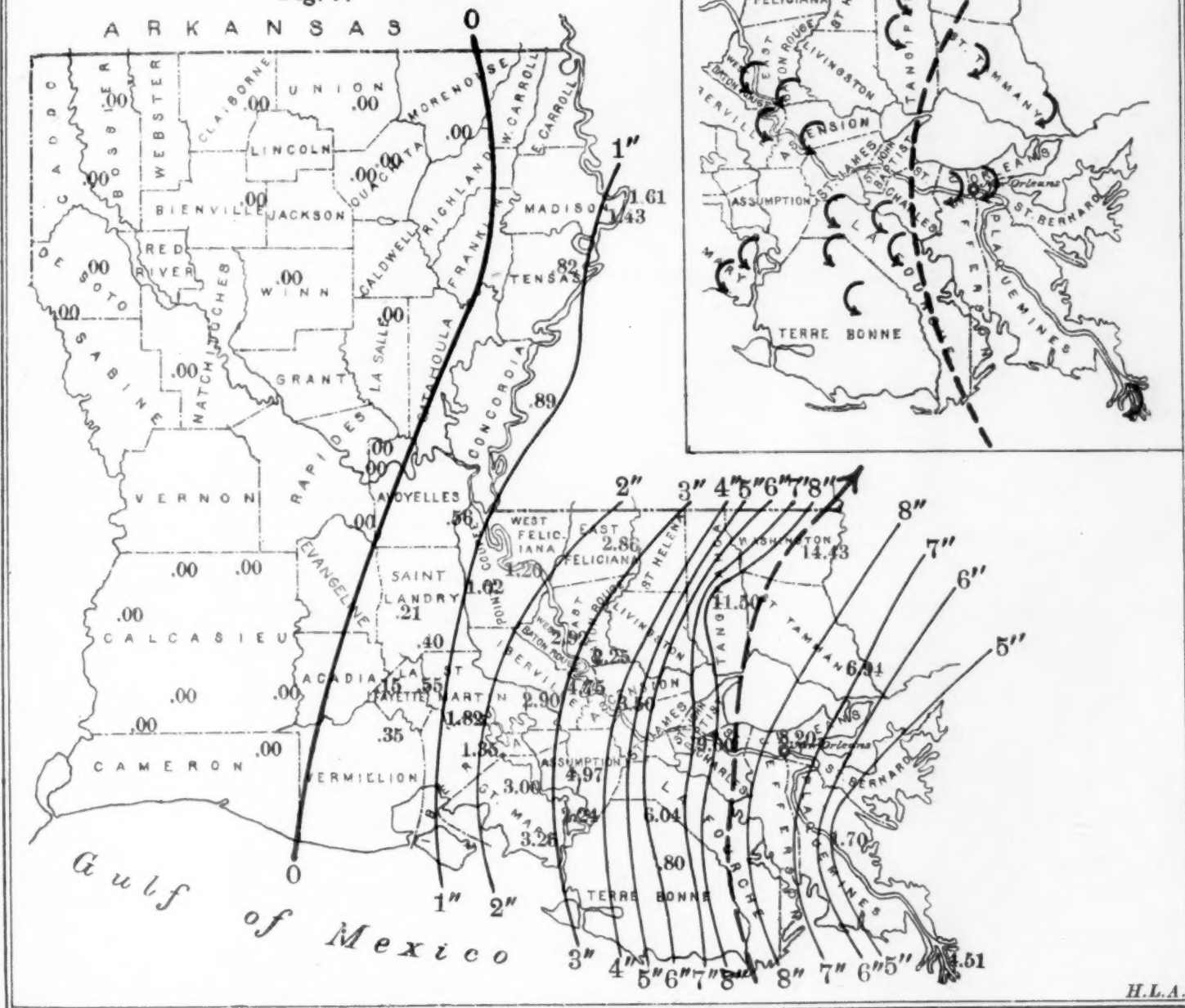


Fig. 7.



I. M. C. Fig. 5. Barogram at New Orleans, La. Fig. 6. Wind changes along the hurricane track.

1. M. C. **Fig. 7.** Rainfall either side of the hurricane.